THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

Volume 15 FEBRUARY, 1936 Number 2

Photograph by J. G. Nussbaumer

Ernest Mayer, Charter Member of the American Ceramic Society and its first Vice-President, was recognized in England and America as a master of the complicated details of pottery manufacture. **For a brief biography of this Charter Member see page 51.**

ARMCO
ENAMELING IRON

Power
born of smart design and Armco Enameling Iron

BUYERS of your porcelain enameled products look for smart styling first. Then comes efficiency of operation followed closely by beauty of finish and durability. It is the latter two that ARMCO Enameling Iron can help you insure. ARMCO Enameling Iron can also help expedite the sale of your products. While this "world's standard enameling iron" gives you more shop advantages than any other stock you know of, it also gives you a unique *plus value* at the point of sale. "Armco" is the *only* enameling iron that has been consistently advertised in popular national magazines and radio broadcasts. That's why we say it has Sales Power and that's why we say it will profit you to use it. The American Rolling Mill Co., Executive Offices, Middletown, Ohio.

Write for this Valuable Booklet—FREE!

Get a copy of this useful booklet for every salesman who works on porcelain enameled appliance sales.

THE BULLETIN OF THE AMERICAN CERAMIC SOCIETY

Volume 15 February, 1936 Number 2

CONTENTS

Paper 37

Determination of Thermal Conductivity of Refractories—P. Nicholls ... 37

Activities of the Society 52

Annual Meeting News ... 54
Art Division Seeks Names of Prospects ... 63
Corporation Certificates Ready for Members—Photographs ... 65
Editorials ... 52
Why Don't College Graduates Stay Educated?—Christian Gauss ... 52
Why Not "Calcia"?—M. E. Holmes ... 53
Local Section News: Baltimore-Washington; Central Ohio; Michigan-Northwestern Ohio; Pittsburgh ... 64
McCaughey, Fourth Edward Orton, Jr., Fellow Lecturer ... 61
McKinley, President of the Society, 1935–1936 ... 53
Membership Status ... 65
Membership Workers' Record ... 63
Necrology—John E. Hutchinson ... 64
New Members ... 63
Reasons for 1936 Annual Meeting in Columbus, Ohio ... 61
Roster Changes During January ... 63
Saint's Work in Stained Glass ... 62
Student Branch News: Missouri School of Mines and Metallurgy ... 64
Symposium on Body and Glaze Properties, White Wares Division ... 56

Communications—Ceramic History 66

Care of China—Edward Schramm ... 66

Advertisers' Index ... 12

Buyers' Guide ... 9

Editorial and Advertising Offices: 2525 N. High St., Columbus, Ohio.
Publication Office: 20th & Northampton Sts., Easton, Pa.
Executive Office: 2525 N. High St., Columbus, Ohio.
Committee on Publications: L. Navias, *Chairman;* L. J. Trostel, M. F. Beecher, R. M. King, Ross C. Purdy

Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published monthly.
Subscription $1.50 a year. Single numbers twenty-five cents
(Foreign and Canadian postage, 50c additional on subscriptions)

(Copyright 1936, American Ceramic Society, Inc.)

THE WORLD'S PEMCO FINEST

PORCELAIN ENAMELS
OXIDES • CLEANERS
OPACIFIERS
GLAZES and SPECIALTIES

THE PORCELAIN ENAMEL and MANUFACTURING CO.
5602 Eastern Avenue
Baltimore, Maryland, U. S. A.

Ceramic Kilns and Furnaces

Designed
Built
Operated

Our broad experience is at your service.

We represent the Ferro Enamel Corporation, Cleveland, Ohio, as sales agents for its complete and successful line of ceramic glazes.

ALLIED ENGINEERING COMPANY

4150 E. 56th STREET CLEVELAND, OHIO

(A SUBSIDIARY OF FERRO ENAMEL CORPORATION, CLEVELAND, O.)

Try a Mixture of our NoKarb (**LOW** shrinkage / plasticity) Georgia Clay and **EPK** (**HIGH** shrinkage / plasticity) Florida Clay as the china clay content of your pottery body.

EDGAR PLASTIC KAOLIN CO.
Home Office—Metuchen, N. J.

EDGAR BROTHERS CO.
New York Office—50 Church St.

Mines in Georgia and Florida

AMERICAN CERAMIC SOCIETY

38th Annual Meeting

Columbus, Ohio

- Make your plans to attend this Meeting.
- The complete program will be published in the March *Bulletin*.

FOR FINER FINISHES USE

FERRO CLAYS

Write for Prices and Information

FERRO ENAMEL CORPORATION
CLEVELAND, OHIO

DIRECTORY FOR THE BRITISH GLASS INDUSTRY

Third Edition, entirely Revised and Reset

CONTENTS

Particulars and classified lists of (a) Glass Manufacturers and Craftsmen in all branches of the Glass Industry; (b) Suppliers of Plant Machinery, Furnaces, Raw Materials, Refractory Materials, etc.

Glass Merchants, Industrial Associations, Trade Unions, Educational Institutions, Scientific Societies, Research Associations, Publications (Books and Periodicals).

Demy 8vo (8½ ins. by 5½ ins.) 412 Pages
Price, bound in cloth, 4/-post free

PUBLISHED BY
THE SOCIETY OF GLASS TECHNOLOGY,
DARNALL ROAD,
SHEFFIELD, 9, ENGLAND

SPECIALIZATION—SERVICE
EXPERIENCE—RESEARCH

The Attributes of Success Which Make

Outstanding

VITRO COLORS

Write Us for Samples

Coloring Oxides for Enamels
Resistant Colors for Glass
Overglaze and Underglaze Colors
Glaze Stains
Body Colors

THE VITRO MFG. CO.
Corliss Station,
PITTSBURGH, PA.
16 California St.,
SAN FRANCISCO, CAL.

EFFICIENT MANAGEMENT MAKES GOOD RECORDS

IN 1934 ONE OF OUR LARGE customers constructed a glass-melting furnace (1000 square feet melting area), with 10-inch Corhart throughout the sidewalls in both the melting and refining ends.

At the end of 577 days of elapsed time, 46,326 tons of sheer cuts had been produced—and the furnace was still in excellent condition, without a single weak spot.

During this period a total of 417,978,000 cubic feet of 1020 B.T.U. natural gas was consumed. This included the warming-up period and also a shutdown of two weeks, during which the tank was maintained at operating temperature.

During its eleventh month a carefully observed and recorded fuel survey showed that the "average gas consumption was 811,000 in 24 hours; the average glass output was 115 tons in 24 hours." This is an average of about 7100 cubic feet per ton of glass.

The operator further reports "the best estimate which I could get from the records for a four or five-day period of continuous operation would indicate a gas consumption of between 6700 and 6800 cubic feet per ton of glass."

We believe that these statistics indicate a very excellent performance on the part of those in charge of this furnace operation. We are gratified that such a capable management should see fit to use our product in the construction of its furnaces . . . . . Corhart Refractories Co., *Incorporated*, 16th and Lee Streets, Louisville, Ky. *In Europe:* L'Electro Refractaire, Paris. *In Japan:* Asahi Glass Co., Tokio.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

THE BULLETIN

OF THE AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society and Promotion of Coöperative Research of Technical, Scientific, and Art Questions

Volume 15 February, 1936 Number 2

PAPER

DETERMINATION OF THERMAL CONDUCTIVITY OF REFRACTORIES*

REPORT FOR AMERICAN SOCIETY FOR TESTING MATERIALS, SUBCOMMITTEE C-8

By P. Nicholls†

I. Introduction

One of the assignments of Subcommittee C-8 on Heat Transfer and Refractory Insulation of the American Society for Testing Materials is to recommend a specification for the determination of the thermal conductivity of refractory materials. It is well known that the values for the same nominal material as determined by different investigators have varied widely; therefore, the first step was to establish the accuracy of the possible methods.

It is not the function of the author to report the activities of the Committee except to say that six laboratories undertook to make tests on two makes of brick. Test samples were prepared by two manufacturers, and every precaution was taken to insure that the samples sent to the laboratories were similar. The results of the tests have been given in six papers presented before the American Ceramic Society (see Table I). The thermal conductivities reported in these papers differ materially, and the Committee requested this author[1] to study and discuss the reports and, if possible, to make suggestions for future procedure.

Note: Although the following report was written for the Committee, it has not been formally adopted as a Committee action, and it must not be assumed that the members agree individually with the statements or conclusions.

Table I lists the papers and authors; they are given letter designations which will be used for brevity. The first six include the reports of the tests; *G*, *H*, and *I* are necessary references.

It is not possible to summarize the papers and they must be consulted for fuller details. Table II briefly describes the methods, and Fig. 1 shows diagrammatically the methods as described in Table II; the diagrams only illustrate principles and do not show construction or variations used. Table III (p. 41) gives the area and thickness of the specimen through which the measured heat flow passed.

II. Results of Tests of Committee Samples

The materials selected by the Subcommittee for the first series of comparative tests were (1) a silica brick, Star brand‡ and (2) a fireclay brick, Mexko brand**. Figure 2 shows the thermal conductivities as given in the reports listed in Table

* Contribution from the Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa. Published by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.) Received December 19, 1935.

† Supervising Engineer, Fuels Section, Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa.

[1] The term "this author" refers to the author of this paper to distinguish from the authors of the various papers which are reviewed.

‡ Supplied by the Harbison-Walker Refractories Co.

** Supplied by A. P. Green Fire Brick Co.

TABLE I
LIST OF PAPERS

Designation	Authors	Laboratory or notes	Publication
A	Wilkes, G. B.	Massachusetts Institute of Technology, Cambridge, Mass.	*Jour. Amer. Ceram. Soc.*, **17** [6] 173–77 (1934).
B	Austin, J. B., and Pierce, R. H. H., Jr.	Research Lab., U. S. Steel Corp., Kearny, N. J.	*Ibid.*, **18** [2] 48–54 (1935).
C	Finck, J. L.	J. L. Finck Lab., Washington, D. C.	*Ibid.*, **18** [1] 6–12 (1935).
D	Weinland, C. E.	Johns-Manville Research Lab., Manville, N. J.	*Ibid.*, **17** [7] 194–202 (1934).
E	Peterson, C. A.	Armstrong Cork Co., Central Technical Lab., Lancaster, Pa.	*Ibid.*, **18** [4] 128–34 (1935).
F	Heilman, R. H. and Bradley, R. S.	Mellon Institute, Pittsburgh, Pa. A. P. Green Fire Brick Co., Mexico, Mo.	*Ibid.*, **18** [2] 43–48 (1935).
G	Wilkes, G. B.	(Describes apparatus used in *A*)	*Ibid.*, **16** [3] 175–230 (1933).
H	Heilman, R. H.	(Describes a guarded hot-plate method with samples on both sides)	*Trans. Amer. Inst. Chem. Engrs.*, **18**, 283–93 (1926).
I	Hartmann, M. L.	(Describes a guarded hot-plate method with samples on both sides)	*Proc. Amer. Soc. Testing Materials*, **28** [Part 2] 820–47 (1928).

I or reported to the Committee at a later date; if the test points did not give a smooth curve the mean curve suggested by each author has been used.

The horizontal scale is designated as "temperature," which is the correct basis for making comparisons. The term "mean temperature" is used in most of the reports; the substitution of the term "temperature" is correct for the plots of Fig. 2 which are straight lines; those portions of

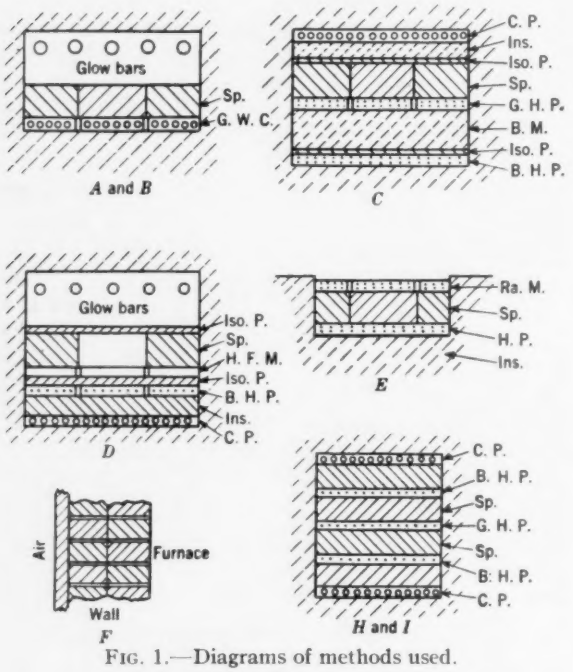


FIG. 1.—Diagrams of methods used.

B.H.P. (balancing hot plate)
B.M. (balancing meter)
C.P. (cold plate)
G.H.P. (guarded hot plate)
G.W.C. (guarded water calorimeter)
H.P. (hot plate)
H.F.M. (heat flowmeter)
Iso.P. (isothermal plate)
Ra.M. (radiation meter)
Sp. (specimen)

TABLE II
OUTLINE OF METHODS

(*A*) Heat supplied by glow bars above the specimen and measured by a guarded water-calorimeter on the cold side.

(*B*) Same as *A* except for area of specimen.

(*C*) Guarded hot plate with another hot plate below, but separated from the first by insulation; equalization of the temperature of the upper and lower plates compels all the heat from the upper plate to flow through the specimen; thus the heat is measured by the electrical input to the center of the upper plate.

(*D*) Uses a heat flowmeter consisting of a plate of Alundum $^1/_2$ inch thick with differential thermocouples in series embedded on the surfaces. The plate is calibrated on the same principle as used in *C*, the heat flowing upward. In tests where high temperatures are required, the meter is placed below the specimen, and heat is supplied by glow bars, as in *A* and *B*.

(*E*) Uses two guarded hot plates with the specimen between them; the upper surface of the top plate is exposed to the air; this surface is plated and polished and acts as a radiation meter. During calibration of the meter, the lower plate acts as a guard so that all the heat supplied to the upper plate passes out of its exposed surface and thus gives a calibration of heat flow against surface temperature. During tests of specimens no current is supplied to the center of the upper plate so that its surface temperature gives the heat which passes from the lower plate through the specimens; enough current is supplied to the guard ring of the upper plate to equalize the temperature of the guard with the center.

(*F*) Test panels are built into the walls of a specially constructed furnace, gas-fired, 6 by 10 ft. and 8 ft. high, inside dimensions; the walls are 2 brick (9 in.) thick with $1^1/_2$-inch block insulation outside. Thermocouples give the drop in temperature through each brick and through the insulation; on the completion of the tests, samples are cut from the insulation and calibrated for heat flow in the apparatus of method *H*.

(*H*) Samples are placed each side of a guarded hot plate, so that the conductivity determined is the mean for the two samples; two other guarded plates exactly similar to the center one can be used to produce any desired mean temperature.

(*I*) Similar to *H* in principle, except that use is not made of the two extra plates; in later designs the two extra plates are used, and all are faced with $^1/_4$-inch nickel.

the plots which are curved do not represent the true conductivity and, if corrected, the curvatures would be decreased somewhat. In reports *A* and *G*, Wilkes gives a relatively simple method for deriving true conductivity from over-all test results; this author[2] discussed the conditions of test necessary to permit conversion and derived a graphical method.

Inspection of Fig. 2 shows wide variations for both materials; the few deductions warranted

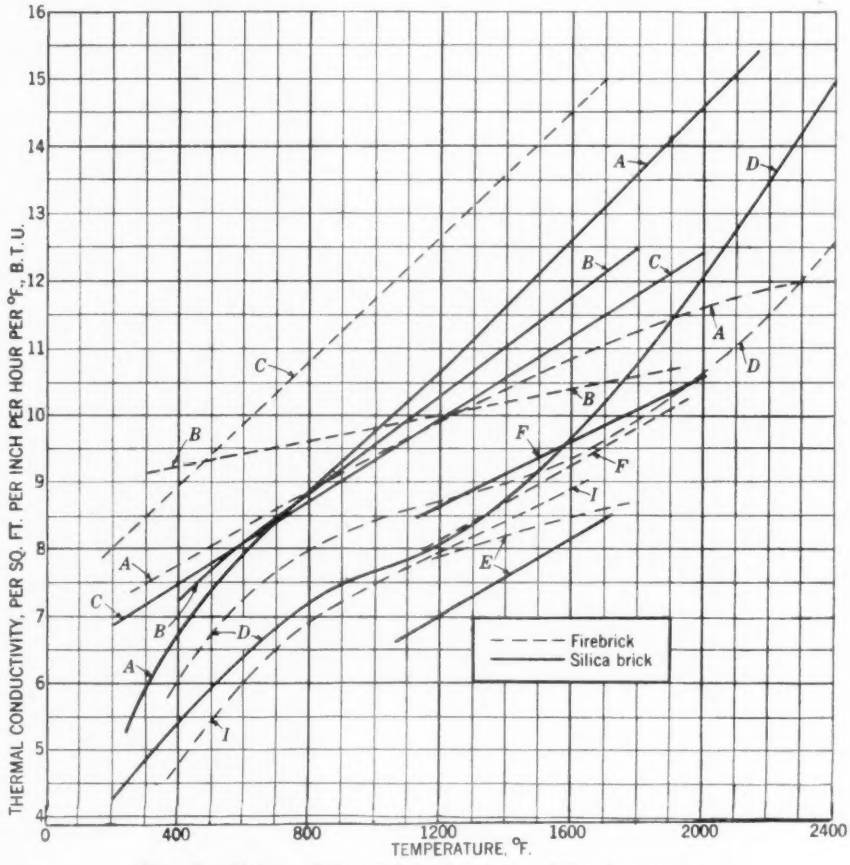


FIG. 2.—Values of thermal conductivity of the six reports.

are as follows: (1) The relationship of the curves for silica and fire brick is of the same order in *A*, *B*, *D*, *E*, and *F*, and this relationship is in closer agreement than are the results of the different reports. The natural deduction is that the disagreements are not caused by the samples tested not having the same properties but are a function of the apparatus. (2) An exception to (1) is the relative values for silica and fire brick from report *C;* in contradiction to the others, the curve for fire brick diverges from that for silica instead of crossing it. (3) The agreement at low is no better than that at high temperatures; in fact, the percentage values of the differences are somewhat worse. The more probable deduction is that, if k varies as $\frac{\text{B.t.u.}}{\Delta t}$, the measured value of one of the quantities is materially in error, and that type of error persists over the range of test and causes the major part of the differences. (4) The curves for both bricks of report *D* have an S-shape, which is absent in all the others; the area of specimen tested included vertical joints, and the upward turn of the curve may be caused by radiation through the joints at high temperatures. Author *D* also tested the fire brick in the apparatus of *I* and obtained curve *I;* it is of interest that curve *I* parallels curve *D* and shows the same *S*-tendency. (5) The best agreement is for the silica of *A*, *B*, and *C*, for which the curves intersect at 700°, although at 2000° *A* and *C* differ by 16%. The methods of *A* and *B* are essentially duplicates, and the results they give are more likely to agree, independent of their actual truth.

All the reports outline the precautions and care taken, but in no report are there independent measures given of the same quantity. There is only one measure of the rate of heat flow, and all use only one thermocouple on each face of the specimen except *D*, in which there were two couples for the 81-square inch area, although individual readings are not given in the report.

Suggestions for possible causes of error follow: the factors involved in these suggestions will be discussed later. The possibility of instrumental errors is not considered, nor are those involved

[2] P. Nicholls, "The Derivation of True Thermal Conductivity Coefficient from Overall Test Results," *Jour. Amer. Soc. Heating Ventilating Engrs.*, **28**, 325–42 (1922).

in the measurement of the surface temperature of the specimens.

(1) Reports A and B

The apparatus of *A* and *B* were nearly duplicates and give approximately the same results, except that there is a material difference in the temperature coefficient, those of *B* being less; the factor causing this difference is consistently proportional to the heat flow. Since they used different instruments it would follow that the instruments had the same order of accuracy. The possible sources of error suggested are as follows:

(1) Heat leakage across the gap between the center and guard of the water calorimeter. The authors do not report any investigation of the temperature differences across the gap. The grooving for the water channels was not such as to give the same temperature around the gap for either the center or guard, although there would be a tendency to equalize the temperature over the face by conduction through the brass. Report *A* shows that the rise in the temperature of the water was of the order of 20°F for 250 B.t.u. per hour input to the 3-inch square center; assuming that the difference in temperature was half the rise in the temperature of the water, or 10°F, the heat flow across the $^1/_{32}$-inch gap for the $^3/_8$-inch thick plate would be of the order of 5 B.t.u. per hour, or 2% error. With good regulation of the water to the guard, the advantage of the calorimeter used at atmospheric temperatures is that there would be little probability of large losses, although it would be better to have some check on the gap loss.

(2) Heat leakage from the lower face of the calorimeter. These authors depend on a large thickness of low-conductivity material and do not use a guard plate. Any computed maximum loss would be small, but again a check would be worth while; suggestions will be made later.

(3) There is the possibility of heating of the upper faces of the specimen by the glow bars not giving the same temperature and of the lines of flow through the specimen not being parallel. The authors state that they have made special tests to check the temperature distribution of the upper face and found it closely uniform.

(4) Incorrect values for the rise in temperature of the water could cause large errors, and the accuracy of the method is entirely dependent on this measurement. The agreement of the mean values obtained by *A* and *B* is an indication that they had either the same or small errors.

(5) The results of both authors show a large drop in temperature across the narrow gap between the specimen and the face of the calorimeter; furthermore, the meaning of the temperatures registered by the thermocouples on the upper face requires investigation because of the high proportion of radiant heat.

(2) Report C

The guarded hot plate shows careful design and has the desirable feature of being metal-faced.

(1) Sil-O-Cel powder is used around the specimen to act as the guard material; it will be shown later that this introduces possibilities of leakage, though they are reduced by the metal facing.

(2) There may be a question on the accuracy of the guarding of heat flow from the underside of the hot plate because of lack of uniformity of temperature conditions there, but the relatively great thickness of Sil-O-Cel should insure that the error will not be large.

(3) The author insures better straight-line flow by using metal plates to produce isothermal planes. These plates introduce high heat capacity into the system and it will require longer to determine whether constant conditions are attained and, consequently, individual values are more likely to be in error.

(3) Report D

(1) Although a heat flowmeter is used, its calibration depends on the accuracy of the guarded hot plate. The hot plate has no metal facing and, as will be discussed later, such a design is more liable to error, particularly with the heat flow from one side only.

(2) The area of the specimen was 9 by 9 inches and included a vertical joint; there can be question whether one is justified in comparing the results with those for which there was no joint.

(3) A permanently constructed heat flowmeter is a useful tool, but the values it gives may depend on its position and the type of contact made by its faces; many careful checks are required to insure that the calibration is the same for all its applications.

(4) Report E

In judging the accuracy of the values of report

E, allowance must be made because the tests of the Committee's samples were the first used with this method and apparatus. Surface radiation as a means of measuring heat flow is a useful tool, but one would hesitate to accept the values as correct until there was confirmation, particularly for a plate in a horizontal position with a polished surface. The convection loss depends on the motion of the waves of air sweeping the plate and then rising; the motions will be complex and possibly may be easily affected by a small change in surrounding conditions; not only may the guard ring have to be at the same temperature as the center, but also the surface of the insulation surrounding the guard at the same temperature as during the calibration.

The accuracy of the calibration of the radiation meter depends on its accuracy as a guarded hot plate; during calibration, the plot of temperature through the hot plate differs from that when it is used as a meter, and the effectiveness of the guarding under the two conditions may not be the same. The principle, however, adopted by the author of using the differentially wound strips for guarding should give the best assurance that there is no heat flow across the gap, although its application will depend on the location of the junctions in the section through the hot plate; at least they should all be in the same horizontal plane because the temperatures at different planes of the hot plate are not the same either during calibration or tests of samples.

(5) Report F

The apparatus of this report was destroyed by fire, and points at two rates only were obtained. The method is, in effect, an application of a heat flowmeter on the outside of the wall of the furnace, except that the meter was calibrated after the tests.

(1) In using certain bricks in the wall of a furnace as the specimens, the results might be affected by filtration of air or hot gases through the wall if the pressures on the two sides of the wall were not the same. If there were filtration, the conductivity as computed would be the apparent[3] and not the true. One would think that the magnitude of such filtration would be small in a specially built test furnace, but filtration is less likely in the other methods.

(2) The hot plate used in calibrating the insulation (described in report *H*) has the center and guard sections in one piece, and the line of demarcation between them is based on the area covered by their windings; one would hesitate before accepting any assumption as to what the correct area is or that it will be the same for all rates of heat flow.

(3) As the plate is used for two-sided flow, there will be better temperature distribution than with one-sided flow, but not being metal-faced the equalization of the temperature between the center and guard by temperatures taken on the surfaces of the Alundum may be in error.

(6) Report I

The one curve shown in Fig. 2 was made with a guarded hot plate embodying the same principles as discussed under report *F*, and the comments on items 2 and 3 of *F* apply.

III. Summary of Analysis of Reports

The causes for possible error discussed in the foregoing are not positive enough to fix any one set of results as assuredly in error, and it does not seem that such causes would produce major differences. Each author has been thorough and has tried to eliminate possible errors and, until the truth has been determined by a thorough investigation, there is no just basis for discrediting any one method of test.

Although the reports do not include independent measurements of the primary quantities, some authors made duplicate tests and obtained relatively close agreement. Thus, the apparatus of *A* and *B* are closely similar, and the results obtained are of the same order. The author of *B* made repeat tests after reassembling the setup. The author of *C* checked his results by using two test samples in series and also reversed their positions.

TABLE III

DIMENSIONS OF TEST SAMPLES IN INCHES

Method	*A*	*B*	*C*	*D*	*E*	*F*	*H*	*I*
Face (in.)	3 x 3	3 x 5	4*	9 x 9	4 x 4	9 x 2½	6*	4*
Thickness (in.)	2½	2½	1	2½	1	4½		

* Diameter.

As stated, inaccuracies due to instrumental errors can not be judged, but they are always a possibility, especially in individual tests.

[3] P. Nicholls, "Measuring Heat Transmission in Building Structures and a Heat-Transmission Meter" (Appendix D), *Jour. Amer. Soc. Heating Ventilating Engrs.*, **30**, 100 (1924).

IV. Discussion of Some Possible Cause of Errors

This section will discuss in more detail the factors that may cause error in results. Many of the points discussed will have been considered by investigators, but to this author's knowledge they have not been treated previously.

(1) Similarity of Material of Test Specimens

It is not probable that differences in results were caused by the individual brick having widely different conductivities, at least not for the silica. Report *C* shows that the conductivity of two samples from different brick was very much the same; report *B* shows that the conductivity of silica brick of other makes was similar to that supplied for the Committee.

(2) Size of Test Specimens

Table III gives the size of the test samples required by each apparatus; the thicknesses are those used for the Committee tests, and each apparatus could use other thicknesses. Apparatus *D* takes two whole brick; *H* and *I* were not originally designed for testing brick.

The area of the sample should not affect the accuracy of the results directly, but indirectly there are several factors, as follows:

(*a*) The ratio of area to thickness as affecting the straight-line flow of the heat. There is little evidence in the reports on which to base an argument of this factor. Report *C* shows that a thickness of silica of 1 and of 2 inches gave approximately the same results, but the test values departed enough from the mean curves to make this evidence questionable. Report *B* gives tests for silica for straights and for splits, but there is no guarantee that the differences found were not due to the material itself.

(*b*) The uniform density of the flow of heat over the area. The uniformity is dependent not only on the specimen but on the setup between the hot and cold isothermal planes; this phase will be discussed later. There will be less departure from uniformity as the area of the specimen is smaller because the surfaces of a small area are more likely to approach a true plane and to be less warped by the heat; distortion may materially affect the distribution of contact-resistance.

(*c*) For the same accuracy, the number of thermocouples on each face should be proportioned to the area.

It seems probable that the smaller area can give greater accuracy in the values obtained for the specimen tested, but unless the material which the specimen represents can be guaranteed for uniformity, the larger area should be more representative; in other words, the smaller area would be better from a scientific standpoint and the larger from a commercial standpoint. There is no evidence to show that the variations in results were attributable to the areas used.

All the authors used the natural thickness of the brick except *C* and *E*, who cut it down to 1 inch. This would introduce a difference if the conductivity of a brick was not uniform through its thickness, which has usually been assumed to be a possibility because of lack of uniformity of firing. No conclusions can be deduced from Fig. 2 because the values obtained by *C* and *E* lie at the top and bottom, respectively, of the group of curves.

(3) Guarding of Hot Plates

The correct construction to insure that there is no flow of heat between the center and guard ring of a guarded hot plate has been a much discussed question even for plates for low-temperature work. In low-temperature work, the plates have always been faced with copper plates which probably have insured a closely uniform temperature over the surface; also the metal facings of the center and guard have been separated by a gap which has facilitated equalizing their temperatures. Calvert and Caldwell[4] and the authors of reports *H* and *I* made their medium-temperature plates of Alundum, did not use a metal facing, and made the center and guard continuous. The construction of all these plates was handicapped by the necessity of bringing the leads from the windings through the plates, because they were used for two-sided flow. As previously stated, this author does not consider that there can be a guarantee of accuracy if the plates are continuous.

The author of *E* does not use a metal facing but makes the center mechanically separate from the guard, and, as the setup requires flow only in one direction from the plate, the leads can be brought out of the other side.

Alundum has a thermal resistance of the order of fire brick; consequently there will be tempera-

[4] R. Calvert and L. Caldwell, "Loss of Heat from Furnace Walls," *Ind. Eng. Chem.*, **16**, 483 (1924).

ture gradients from the heating wire to the face of the plates. It is improbable that the construction of any of these all-Alundum plates is so symmetrical and of such uniform thermal resistance that equalizing the temperature of a few points on the surfaces will insure that there is no heat leakage between the center and guard areas; also, non-uniformity in the surface contact-resistance will result in local distortion of the heat flow and uneven temperatures.

Guarding a plate to be used with test specimens

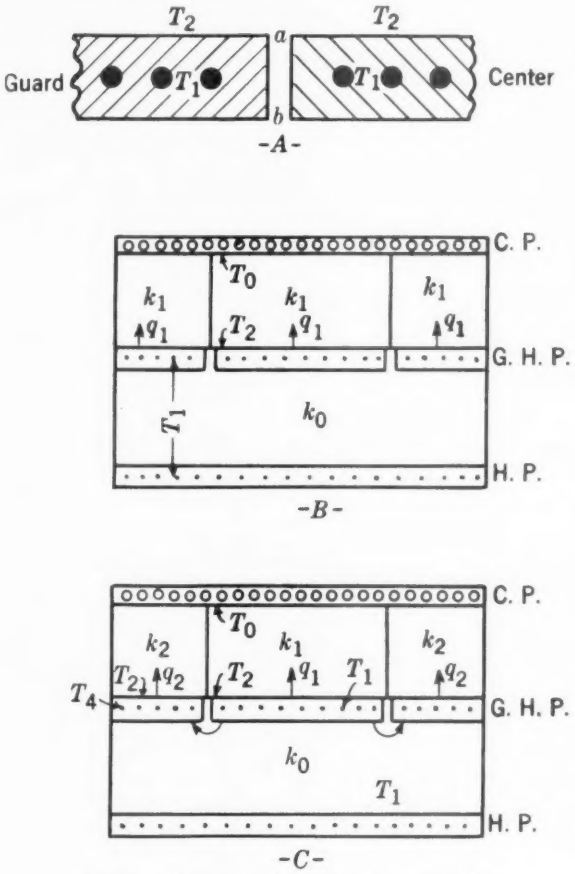


FIG. 3.—Diagrams (see Fig. 1 for legend).

on both sides is simpler than when all the flow is from one side. Figure 3*A* represents an all-Alundum plate. If used for double flow, the temperature of the under-surface will be T_2, the same as the upper surface, and there is at least nominal symmetry. If used for single flow, the temperature of the under-surface will be the same as that of the wires, T_1, and the temperature at a will be uncertain and probably higher than T_2.

The design of a double-flow plate for high temperatures and having metal facings involves difficulties because of bringing out the leads, but metal facings are essential if there is to be a guarantee of good guarding. The single-flow plate of report *C* has metal facing on one side; its design aims to reduce side leakage by using a thick plate and extending the metal over the full depth of the gap. The possibility of there being no downward flow from the under-side of the plate to the bottom guard plate is more doubtful; the lips of the metal facings will have a lower temperature than the equi-temperature zone below the heating windings and may affect the thermocouples in the Alundum pillars.

(4) Guarding for Straight-Line Flow of Heat

The curvature of the lines of flow between the hot and cold plate was treated by Van Dusen[5] for the simple conditions in which the two plates have metal facings, and the material between the whole area of the plates and beyond them is uniform and has the same conductivity. He shows the effect of the relation between thickness of specimen and width of guard ring. The conditions, however, are not always simple and there is a requirement which may have been overlooked because it has not been discussed in reports. The requirement is that the temperature gradients in the specimen and in the guard material at their planes of contact should be the same or there will be cross flow of heat.

The more complicated conditions occur with one-sided flow. Figure 3*B* represents a setup in which the material between the guard rings is the same as the test specimen; this corresponds to Van Dusen's assumptions. The density of the flow of heat from the guard ring will be the same as that from the center, and the temperature gradient from the heating wires to the cold plate should be the same for both center and guard, whether the hot plate is metal-faced or not.

Figure 3*C* shows a specimen of conductivity, k_1, and a material of lower conductivity, k_2, over the guard. The unit heat flow, q_2, from the guard will be less than q_1 from the center; therefore, if the surface temperatures are the same, the drop in temperature through the Alundum will make the temperature of the heating wire of the guard lower than that of the wire of the center; consequently, the temperature of the under-side

[5] M. S. Van Dusen, "Thermal Conductivity of Heat Insulators," *Jour. Amer. Soc. Heating Ventilating Engrs.*, **26**, 404 (1920).

of the guard will be lower than that of the center and there can be flow between them.

Assuming that the temperatures of the upper surface of the center and guard plates are the same, the temperature gradients from T_2 to T_0 of the planes of contact of test and guard specimens will be the same (*a*) if the drops in temperature across the contact-resistances are the same (this is improbable if the unit heat flows are not the same), and (*b*) if the temperature gradients of k_1 and k_2 are the same (this also is not probable).

The magnitude of the possible error would be greater if there were a layer of material having k_3, different from k_2 or k_1, over the whole area on either the hot or cold face, because there would be definite differences of temperature along the plane of contact of test and guard specimens independent of the temperature gradients of the three materials.

The possibility of error is less if the faces of the hot and cold plates are metal. For instance, if the same material is used over the whole area of the plate except for a 1-inch wide annular ring surrounding the test area (as has been done by the author of *A*), and if the plates are metal-faced, the errors will be limited to causes *a* and *b*, and the straight-line flow would not be otherwise disturbed; if the plates were not metal-faced the errors would be larger because the temperature drop from the heating wires of the hot plate to the surface of the Alundum would not be the same below the guard as for the center.

It is not possible to measure the magnitude of these errors, and it is safer to avoid them by using the same material over the guard as over the center. This reduces the possible distortion of heat flow to the simpler conditions treated by Van Dusen. In the opinion of this author, for exact work this distortion should be counteracted by guarding; if this can not be done by adjustment of the currents in the winding of the guard, it is possible to use heaters on the sides between the hot and cold plates, but it would be necessary that their effectiveness be determined by test. A possibility of such checking will be discussed later.

Allied to the foregoing discussion is the question whether there is less probability of error by making the area of the specimen correspond to that of the center plate plus half the gap between center and guard or by extending the specimen as one piece so as partly, or completely, to cover the guard plate. The advantages of letting the specimen overlap are as follows:

(1) It avoids the necessity of cutting the specimen to an exact shape and maintaining exact dimensions, which is an important item with refractories.

(2) It avoids errors because of radiation through the joint; if the joint is well over the guard area, only a fraction of the effect of the disturbance would extend to the center area.

(3) The heat flow over the gap area should be uniform, and there is more probability of half of the heat being supplied by both the center and guard.

(4) The effect of shrinkage and warping of the specimen will be largely eliminated.

Consequently, it will be logical to take the effective area of the specimen as the area of the center plate plus one-half the gap. The one possible cause of error is that the surfaces of the center and guard plates may not be on the same level, with the result that the contact-resistances may not be the same and the heat flow will be disturbed.

(5) Alternating and Direct Current

Alternating current was used in all the methods but *C*. The advantages of alternating current, its availability, relative constancy of voltage, and cost, are obvious, but there is the possibility that errors may be caused by inductive effects of the circuits on each other; it would be safer to check the apparatus by using direct current. This author's practice was to use alternating current for bringing up to approximate constancy and then to finish with direct current.

(6) Surface-Temperature Measurements

The measurement of surface temperatures has always been an uncertainty in heat-transmission work because there is no means of checking the correctness other than by using a number of thermocouples. This is expensive when rare metal must be used, but duplicate couples should have been used in these special tests; since they were not, the data give little opportunity for deducing whether errors in temperature drop, as measured through the specimen, caused the differences in the conductivities obtained.

The investigators, with the exception of *F*, located the thermocouple wires as near the surface as they could, cementing them in place; thus, if the surface contact-resistance were large the junctions would be in a position of critical

temperature. Data from which drop in temperature at the surface can be derived are given only in three instances, but they are of interest.

In method *A*, the temperature of the water calorimeter is known approximately; there was $^1/_{16}$-inch asbestos paper between the plate and the specimen. Table IV shows the pertinent data.

TABLE IV
DATA FROM REPORT *A*

B.t.u./hr./ft.²	Temperature drop, °F through $2^1/_2$-in. brick	Temperature drop, °F through $^1/_{16}$-in. asbestos	Apparent *k* of asbestos
573	166	95	0.24
1390	419	356	0.24
2240	599	502	0.28
3790	862	724	0.33
5420	1089	900	0.38

The table shows that the drop through the $^1/_{16}$-inch asbestos approaches that through the $2^1/_2$-inch brick; therefore, there would be a sharp change in the temperature gradient, and it might be a delicate question where this change occurs. It is quite possible that the contact-resistance would vary and that the temperature over the surface of the specimen was not uniform.

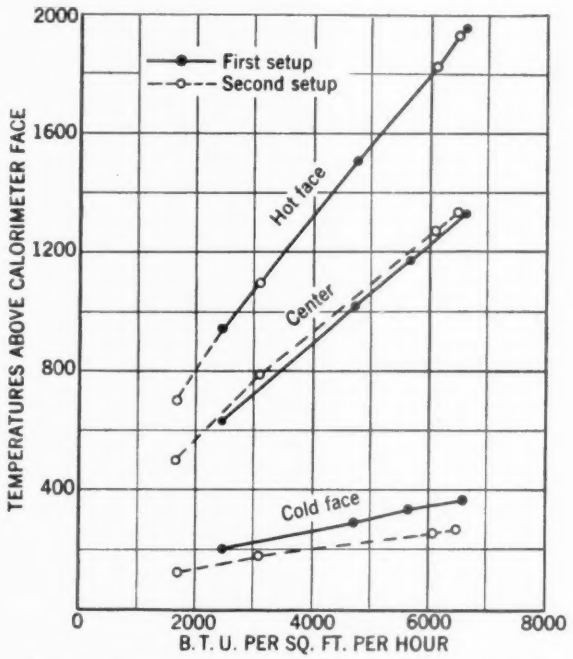


FIG. 4.—Plot of test data for silica brick of report *B*.

The author of report *B* has supplied detailed data which show that appreciable variations can occur. The setup was similar to that of *A* except that instead of using an asbestos sheet, the face of the calorimeter was sprinkled with ground silica brick to a thickness of about 0.04 inch. After a complete set of tests, the setup was disassembled and the couples were removed; then the apparatus was reassembled. With the silica brick, there was a 6% change in conductivity. Figure 4 is a plot of the two tests in which the temperature above that of the calorimeter for the hot and cold sides of the specimen are plotted against the rate of heat flow. The plot shows that the difference in the two tests was caused by about 80°F difference in the measured temperature of the cold face of the brick, that of the hot face being exactly the same. It would require a 0.13-inch thickness of brick to account for the 80°; such a shift in position is not likely, and the change in temperature was probably caused by a change in the surface conditions.

The data for fire brick are not given in report *B*, but were supplied by the author; the repeat test gave a difference in conductivity of about 5%. The plot of the data shows that the differences between the temperatures were 60°F for the hot face, 20°F for the center couples, and 110°F for the cold face; the change in values was therefore also due to the cold face.

The author of *C* made tests of heat flow with two similar specimens in series and had couples on each surface; in contradiction to the foregoing, the temperature drop between the surfaces was quite small, as shown by the following:

	Silica					Fire clay		
B.t.u./hr./ft.²	88.0	935	1395	1980	2160	563	893	1460
Surface (°F)	250.0	686	1117	1565	1745	405	760	1475
Drop (°F)	3.4	−1.0	1.4	12	16	2.4	1	11

According to these results there could have been little possible error in this temperature measurement. The small contact-resistance is of interest. Is it low because surfaces of similar materials were in contact?

Several investigators have stated that there are larger variations in the measurements of the temperatures of the cold than of the hot surfaces. This could be explained if the temperatures were measured across an air gap because the radiation factor would be large at high temperature, and thus variations in the width of the gap would have less effect.

V. Summary of Causes of Errors

No attempt has been made to give quantitative values for possible causes of errors. The reports themselves recognize and compute some

possibilities, but the percentage of possible error as estimated is small in each instance. This author does not think that estimates could be accepted as proof, but that a thorough investigation, such as will be suggested, should be undertaken.

VI. Suggestions for Thorough Analytical Investigation

During the past twenty years many investigators have devised methods and apparatus for determining the thermal conductivity of high-temperature insulators and refractories; usually they have spared neither pains nor expense in attempting to insure that their results would be correct, but, as this author recalls the reports, in no single instance was there any attempt to devise a system of measurements that would fix the limits of the absolute accuracy of the results.

Repeat tests do not fix the limits of accuracy. Duplication of results for one material by entirely different methods gives some assurance, and duplication for several materials having rather widely different properties would give still further assurance. Such duplications can be found for investigations at normal temperatures.

Although proof by duplication of overall results is assuring, more confidence is created if, in addition, each investigation includes proofs of the accuracy of measurements or of subsidiary factors of the overall results, obtained by duplication of measurements and by side investigation, respectively.

The conviction of this author is that a thorough investigation is required with the main object of clearing up the present doubt and demonstrating that assured values for conductivity can be obtained. Suggestions for such an investigation follow; the discussion is concerned only with the direct measurement of conductivity and does not include methods based on determination of diffusivity because that involves the equally debatable determination of specific heat at high temperatures.

(1) General Problem

There are three general factors involved in the accuracy of the conductivity measurement:

(1) The accuracy of the instruments used for measuring quantities; this factor will not be discussed.

(2) The establishment of temperature equilibrium; this will not be discussed because it can be done and its existence proved.

(3) In the expression,

$$k = \frac{Q}{A} \times \frac{T_1 - T_2}{L},$$

the assurance that (*a*) the measured quantity of heat, Q (all and no more), passes into the measured area, A, for the length, L, and leaves the specimen through the same area, A, and (*b*) T_1 and T_2 are the correct temperatures of the areas, A, at the extremities of the length, L, and as subsidiary desirables, (*c*) the heat flow is uniformly distributed over the area, A, throughout the length, L, and (*d*) the planes at the ends of L are isothermal.

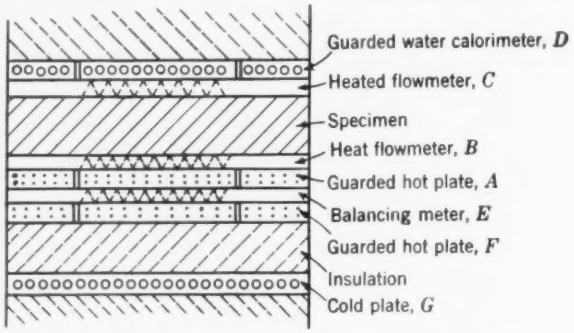


FIG. 5.—Setup to check heat-flow measurements.

Items (*a*) and (*c*) will be considered first.

(2) General Method

The methods used in refractory investigations have included only one measurement of rate of heat flow. In the low-temperature field, this author concluded that it was necessary to be able to measure the heat flow in more than one plane of the flow; he therefore developed[6] the differential-couple heat flowmeter as an additional instrument. Having such meters, one can be placed on each face of the specimen and will give the rate of flow into and out of the specimen. If, in addition, the heat is supplied by a hot plate, so guarded that all the heat flows into the specimen, there are three measures of the rate of heat flow. If, further, the cold plate is a guarded water calorimeter, there are four measures of the heat flow.

[6] (*a*) P. Nicholls, "Measuring Heat Transmission in Building Structures and a Heat-Transmission Meter," *Jour. Amer. Soc. Heating Ventilating Engrs.*, **30**, 65–102 (1924).

(*b*) P. Nicholls, "Practical Application of the Heat-Flow Meter" (Appendix), *ibid.*, **30**, 299–300 (1924).

Figure 5 shows such a setup diagrammatically. If the four instruments, *A*, *B*, *C*, and *D*, register the same rate of heat flow, there is fair assurance that each measure of the heat flow is correct and that the heat flow in and out of the specimen is the same. If the readings of *A* and *B* are the same, but different from those of *B* and *C*, the indication would be that the lines of heat flow are not straight.

If all were the same, neglecting face-temperature measurement for the time being, the only factor in question would be the area through which the measured amount of heat was flowing. If the specimen overlapped the gap between the center and guard and the other conditions for uniformity were fulfilled, there would be little doubt but that the area would be that of the center plus half the gap area, but it would be difficult to prove that this assumption was correct; an attempt might be as follows:

First, make a test using a specimen that overlaps onto the guard; then, without removing the face couples, cut down the specimen so that it includes half the gap and have a $^1/_4$-inch width between the sides of the specimen and the similar material over the remainder of the guard; fill this space with a powder having a conductivity lower than that of the specimen. Repeat the test using the same heat flow; if the specimen is not too small, the temperature drop should be the same. A similar test with the specimen cut down to have the same area as the center plate should give a higher temperature drop.

The assumption of the plan is that the $^1/_4$-inch low-conductivity powder will not deflect the lines of heat. This subject has been discussed previously; the hot and cold plates must be metal-faced, but still there may be some tendency for leakage if the temperature coefficients of the specimen and powder are not the same. The plan has not much to recommend it, but the effect of such changes should be instructive.

There should be no need to test for uniform distribution of heat flow over the area of the specimen unless the area is large. This author made such tests in low-temperature apparatus by dividing the winding of the heat flowmeters into two sections. It requires several tests, however, to determine whether the difference in readings between the two halves is not due to the difference in thermal conductivity of the plate between the differential couples.

(3) Procedure for Proposed Methods

The procedure would depend on the design of the hot plates. Figure 5 represents them as two-sided flows which, in principle, give more latitude in cross-checking because the total output of the center can be accounted for in calibrating the heat flowmeter by placing one meter on each side after having calibrated them in series. It would be possible to construct such a plate, but probably the metal facings would have to be loose and would make a poor construction. The principles of the procedure will be illustrated on the assumption that it is necessary to use single-flow hot plates. This author, however, believes it would be better to abandon the attempt to carry the application of hot plates to the highest temperatures and to limit their maximum temperature to below 1800 or possibly 1600°F, and to use the glow-bar method for high temperatures. This would leave a gap between 1800 and 2600°F for which there would be no check, but at the higher temperatures the cause of possible error would be limited to the assumption of straight-line flow, because the accuracy of the calorimeter or heat flowmeter measuring the quantity of heat would not be affected by the higher temperature.

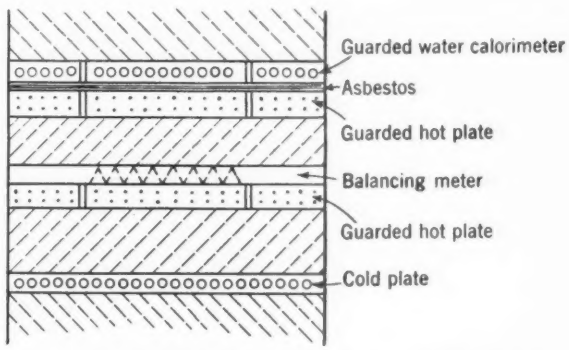


FIG. 6.—Setup for comparing hot plate and calorimeters.

The principles of the procedure would be as outlined in the following:

Test hot plate against water calorimeter with setup shown in Fig. 6. If the heat measurements of the hot plate and calorimeter do not agree, the reason would have to be found through the ingenuity of the investigator. The relations of the values at different rates might suggest the cause, and the effect of changing the adjustments of the various guardings in turn would be a useful tool. This phase of the work should be very instructive.

Calibrate the heat flowmeters with setup of Fig. 6 except that two heat flowmeters would replace the asbestos. This would require an extended study and should include the following steps:

(*a*) Agreement should be obtained of readings of hot plate and calorimeter at all rates. As agreement was obtained with a setup having a thin layer between the plates, a disagreement with a thick layer will mean that the flow is not straight and will require a study of changes that can be produced by the guarding. The readings of the heat flowmeters will help in showing the effect of changes. If agreement can not be obtained by adjustment of the guards, it would be an opportunity to try the effect of additional guards around the outer edges of the space between the hot plate and calorimeter.

(*b*) Put a layer of asbestos on each face of meters to determine whether the type of contact affects their readings, as it may do if the differential couples are not sufficiently below the surface.

(*c*) Turn one heat flowmeter through 180° to determine whether the readings are affected.

(*d*) Interchange meters.

(*e*) Turn both meters over so heat flow through them is reversed.

It is safer to make and calibrate three meters to give a reserve for future checking. Each meter should be subjected to a higher temperature than that for which it will be rated.

If all difficulties are overcome, assured calibrations of the heat flowmeters will have been obtained, and they can be used as instruments in further work. Specimens of various materials can be tested in the same setup with and without the meters.

The glow bars could now be introduced as the heat source with setups similar to reports *A* and *B*, and the heat flow could be measured by the calorimeters and heat flowmeters.

The heat flowmeters could be used to check the type of apparatus of report *E* which uses a radiation meter.

(4) Construction of Heat Flowmeter

The construction of the guarded hot plate will not be discussed, since it was covered in the notes on Table I and also in this report. The best design is problematical, and it is quite probable that more than one would have to be constructed. This author leaves it an open question whether it should be one- or two-sided.

A heat flowmeter is described in report *D;* it was made of Alundum and was $^1/_2$-inch thick and 9 inches square; the author has shown that this thickness can withstand the pressure and usage. The construction and calibration of the meters are expensive so they should be strong enough to withstand breakage, but also as thin as possible so as to reduce the temperature drop through them; the necessary thickness would be less as the test area is reduced.

The area of the meter plate should be larger than the center of the guarded hot-plate calorimeter for the reasons advanced for the area of the specimen being larger.

The unit conductance of the plate should be the same all over; the conductance is affected by the wire of the differential couples passing through the plate and a further precaution would be to wind the plate with couples outside the test area, not connecting them to the main differential winding but leaving them dead or, if the guard area is large, completing the differential system of the guard area as it would be useful in the investigational work.

It is a good plan to make the differential system of the test area in two sections, each distributed over half the test area, because it is helpful during the calibration; this can be done by tapping the system at its center; this lead can, if desired, be cut off at the completion of the calibration.

It is necessary to have couples to measure the mean temperature of the plate. One couple on each side of the plate is sufficient; the simplest method is to connect these two couples in parallel either by connecting them in the plate, thus having only one pair of leads from the plate, or by connecting them outside the plate.

The junction and wires should be sunk below the surfaces of the plate as this makes the readings less liable to be affected by the type of contact at the surface, and it also permits the surfaces to be ground during construction; probably $^1/_{32}$ inch would be enough. It should be possible to fill the grooves at such a stage in construction that the material in them will be similar to that in the rest of the plate.

(5) Construction of Plate Calorimeter

A full discussion of factors involved in the calorimeter would be long. Its limits of accuracy will depend mainly on the correct measurement of the temperature drop of the water across the plate. Apart from the thermometric accu-

racy, there may be some question on the heat leakage from the outlet pipes.

The setup for the calorimeter will be comparatively simple if it is assumed, as was apparently done by *A* and *B*, that the errors due to leakage are negligible, but it will become complex if the guarding is to be checked and adjusted to zero flows across the gap and from the rear surface of the plate.

Differentially wound mica strips would have to be used for the side gaps and an average balance obtained, because by no arrangement of the grooves for the water can the temperature around the edges of the center or guard be the same. The grooving of the guard plate used by *B* is adapted to control the flow across the gap by the use of two water circuits, one system being around the gap and the other for the remainder of the guard plate.

The guarding of the rear surface of the plates is complicated because the temperature over the surface is not uniform and because the outlet and inlet pipes have different temperatures. The first step would be to have a balancing meter plate in direct contact with the rear surface. It would consist of $^1/_4$-inch (or thinner) cork flooring in one piece, without any gap between the center and guard areas, to be differentially wound over areas corresponding to the center and guard. It would be backed by more cork flooring to make a solid support for the calorimeter plates and they could all be cemented to make one piece. The balancing hot plate or water plate would come next; it should be preceded, preferably, by another balancing meter similar to the first. The inlet and outlet pipes would pass vertically through all these plates. Such a setup becomes complicated and requires the adjustment of a number of controls.

(6) Investigation on Surface Temperatures

The accuracy of the measured temperature difference per unit of length through the specimen in the direction of heat flow depends on (*a*) the accuracy of the measurement of the distance between the planes in which the couple or couples on each plane lie; (*b*) the accuracy of the reading of a couple as a measurement of the point on the plane in which it lies; (*c*) the accuracy of this point (or points, if more than one couple is used on each plane) as giving the average temperature of the plane; and (*d*) the possible instrumental errors of the couples or instruments used with them in not giving true values for the temperature; this last item need not be discussed.

With the necessary instruments and proper preparation of the specimen, it is possible to measure the position of the junctions to a high order of accuracy. The thermocouple wire can be small if a sensitive potentiometer is used, and the junction can be ground or flattened to make it not much thicker than the wire.

Whether the junction will have the same temperature as the material in the area of the plane in which it lies is a problem of the balance of heat flow in and out of the junction; it is not possible to trace the heat flow because there is no basis on which to assign values to all the conditions involved. Practically, it is a question whether truer values are obtained by burying the wires and of the precautions that should be taken in filling a slot, if one is cut in the specimen.

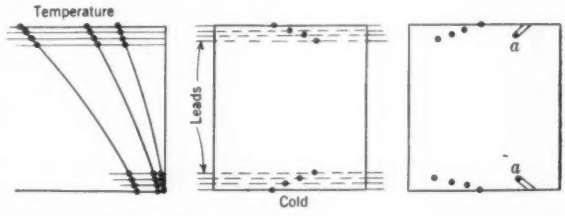


FIG. 7.—Scheme for investigating surface temperatures.

That the temperature of the point is the average of that of the whole area of the specimen can not be proved, but there will be better assurance if more than one couple be used. Putting many wires on the face and bringing out many leads is troublesome and may introduce other errors. There may be some help in connecting couples in parallel, but the electrical resistance of the loops should be approximately the same.[7] The problem is to determine the minimum number of couples to give the desired degree of accuracy.

The following principle of investigation is suggested: Figure 7 shows two views of a test specimen in which the couples form pairs having different depths below the surface. One pair is half in the surface, and the others $^1/_{16}$, $^1/_8$, and $^1/_4$ inch, respectively, below the surface. Make a series of tests at different rates of heat flow. Plot the resulting temperatures on the right, representing them as falling on the curves of the temperatures through the block.

[7] See reference 3, p. 96 (p. 41).

An analysis of the tabulation of the temperatures in connection with the depths of the couples would give some indication as to whether they were in agreement. As a further step, the curve for the true conductivity[7] of the material as given by each pair of couples could be determined. If any two pairs gave correct reading, the true conductivities should be the same; if they differed their relationships would be informative.

The slots cut for the deep couples might introduce differences; the tests could be extended by cutting the slots at an angle as shown at *a;* or fine holes might be drilled at the $^1/_8$- and $^1/_4$-inch depths. The material used for the first tests should have assured uniformity and be easily machined; a natural product such as soapstone or perhaps bentonite could be used as it would not be necessary to go to very high temperatures. Having determined the primary principles, the work with other classes of materials would be simplified.

One would expect that with a homogeneous material free from voids $^1/_{32}$-inch slots would give as correct values as would deeper slots, but it might not be true for granular materials.

VII. General Discussion of Proposed Investigation

It is not implied that tests, such as those suggested, would always result in agreement of values, but it should be possible to determine the sources of error and to narrow their limits. The difficulties and expense involved are recognized. The setups would be complicated, the apparatus would be expensive to construct, and high-class instruments would be necessary. The tests would require constant attention in most of the phases, and the many observations and regulations would probably require two men on some of the shifts.

While an attempt has been made to outline a complete investigation that would be a standard of reference for many years, a less pretentious one could reduce the limits of doubt materially, but it would not be worth while to start any investigation (1) unless all phases of the work were to be high grade, (2) unless there was assurance that it would be continued until completed, and (3) unless it would have sufficient funds.

The first necessity is that a standard area for the test sample should be established. The more thorough investigation could be limited to one area, and it is probable that the work of determining the necessities for accuracy with other areas could be much reduced. An ideal investigation on the accuracy of the methods and apparatus should include two areas of specimen and ageement of the values obtained. The main result of the investigation would be the possibility of writing a specification for the simplest apparatus required for commercial work with an assurance of its order of accuracy.

There is no reason why the principles of design used by each of the authors should not give true values, and there should be the ability to check the accuracy of any type of apparatus. This could be done if a material were available that had constant thermal properties and if the true curve for its conductivity had been determined. It is not probable that there is such a material which would also stand high temperature, but it undoubtedly could be closely approximated in a manufactured brick made to a detailed specification. Such a standard material, or preferably two of different conductivities, will be a necessity for checking apparatus made to the standard design, because accuracy also includes the instruments and their use, and an overall check is desirable.

VIII. Conclusion

This discussion has of necessity been somewhat long because the questions to be considered are those of details rather than general principles, although in the effort to restrict the length of the paper many factors that require detailed discussion have been touched only briefly. The subject warrants even longer discussion; the uncertainty as to the correctness of the thermal conductivity of refractories has been emphasized for the past twenty years, during which time the direct expenditure in testing must have reached large figures. It is time that a concerted effort be made to establish a standard method of test which will give results of a proved order of accuracy. There has been a tendency to imply that it is hopeless to expect accuracy in tests at high temperatures because of uncontrollable or mysterious actions. This author does not believe that such implications are warranted; the mistake has been lack of thoroughness because of lack of continuity by or at one institution. He expressed the same opinion in a review[8] for the National Research

[8] P. Nicholls, "Status of Heat-Transmission and Knowledge in the Refractory Field," *Mech. Eng.*, **48,** 1307–11 (Nov., 1926).

Council in 1926; what was stated then is equally true now: "It is desirable that pure research work should be done to determine the reasons for and the magnitude of variations. . . . Before more work is undertaken there should be a broad plan which will assure its continuation under the same auspices."

It is not implied that application of data on heat transmission in the refractory field to practice necessitates close accuracy for conductivity; the arguments of the paper quoted point out the limitations to accurate predictions because of (1) the inability to define closely the other conditions of service, (2) the lack of constancy of conditions, and (3) the changes that occur in refractories in service.

Acknowledgment

Thanks are expressed to the six authors for their assistance in supplying data requested and for criticism of this paper, which was originally written as a report for the Committee; it does not follow, however, that they individually agree with the statements or conclusions.

ERNEST MAYER

1857 to 1920

Born in Burslem, Staffordshire, England, October 4, 1857, Ernest Mayer was the son of Joseph Mayer of the pottery firm of T. J. and J. Mayer, Dale Hall Works, Burslem. Ernest Mayer was first apprenticed to G. W. Turner and Sons, Tunstall, and later joined Clemenston Brothers, Hanley.

He first attracted notice in the pottery trade by the publication of a pamphlet on an improved method of mixing bodies wet. Shortly after this he originated a new kind of jigger.

In 1878, Mr. Mayer came to New York to join his two brothers who were engaged in the business of importing crockery. For a time he was superintendent of a Baltimore pottery.

In 1881 with his brother, Joseph Mayer, he established what is known today as the Mayer China Company, Beaver Falls, Pa. For forty years he was in active charge of the manufacturing end of this company, well-known producers of hotel china.

Mr. Mayer was a Charter Member of the American Ceramic Society and served as its first Vice-President. He was elected Vice-President of the Society again in 1901 to 1902 and served as President the following year.

ACTIVITIES OF THE SOCIETY

EDITORIAL

WHY DON'T COLLEGE GRADUATES STAY EDUCATED?*

By Christian Gauss

The question "Why don't college graduates stay educated?" can not be summarily dismissed. The college graduate has a better-than-average record for staying out of prison. It is, however, fair to ask: What else do they get out of college, and how much of it do they keep?

Fate of Many Alumni

A college alumnus complained bitterly, "I don't see why school teachers expect us busy college graduates to keep up. My little daughter Susie is only ten, but they teach her things so hard to work out that I just had to give up trying to help her with her homework." Now, the trouble in this poor man's case is not that he was born dumb; he has only become so in the process of the years. It is, alas, the way of the world with many alumni.

This fatty degeneration of too many alumni goes back to a vice not yet eradicated from our college system. During his undergraduate years, the professor gave him lectures, chose his books, and even indicated the pages to be read. He was living under a régime of forced feeding, and when this forcing stopped, what he called his education stopped also. His was not a healthy, vigorous, growing organism. He was never intellectually and culturally self-supporting, but a patient on a supervised diet. He has not been equipped with a self-starter and must be elaborately primed by someone else before he will work. All that he got out of college was the habit of intellectual dependence, and, in spite of his cocksureness, this becomes more painfully evident as he grows older.

Today the student may finish his college course and get his degree without ever having been brought into contact with anything approaching a masterpiece of literature or anything resembling a philosophy of life.

With the disappearance of the liberal arts and the ideal of general culture, "research" has become a very big word in our colleges. It deserves to be. No activity, if carried on by the right people, is likely to yield greater benefits to humanity. But the successful research worker must have qualities far above the ordinary—unusual intelligence, powers of intense concentration, and above all, imagination. But these qualities are rare, and in any given year in all our colleges we can not expect to find more than ten or twenty thousand undergraduates who are capable of achieving results really worth while.

If the graduate school can not make productive scholars of doctors of philosophy, to try to make competent research workers out of run-of-mill undergraduates is clearly impossible. For even if we could succeed in any given year with 10,000 or even 50,000 of them, we must remember that there are annually one million undergraduates in our institutions of higher education; and it is fair to ask what happens to the other 950,000.

Definition of Education

It is as useless to try to make Einsteins or Comptons or Millikans of all our young hopefuls as it would be to try to make Kreislers out of all the children who ever took music lessons.

True masters in research are almost as rare as concert violinists, but their lessons, in the colleges, are paid for out of the public treasury. All our really intelligent research professors will admit that they can not hope to make competent research workers out of every Tom, Dick, and Susie. What are they, the colleges, to do with the immense majority? They will be the butchers, the bankers, the candlestick makers, the milliners, and beauty-parlor experts of 1950.

An education has been defined as what you have left after you have forgotten all the facts you learned in college. In much the same sense, an education is what you have left after you have lost everything that can possibly be taken away from you.

The Greatest Obstacle

In many cases, the college graduate was never really educated at all, if by that phrase we mean that he was trained either to devote himself seriously to any cultural or scholarly ideal, or to that other democratic ideal of deeper devotion to the public interest.

Both are worth training for, but you must select the proper materials and employ the proper methods. In our exuberant faith in mere education, we have not been doing this as carefully as we should. We must take time out to humanize our students and inculcate a deeper sense of responsibility. Before we can do so effectively, we must, however, as professors and alumni, rid ourselves of that complacency which has been and is now the greatest single obstacle that bars significant advance upon any wide front in American college education.

* Condensed from *The Saturday Evening Post*, p. 26 (December 7, 1935).

WHY NOT "CALCIA"?

By M. E. Holmes

Ceramic students are taught, in their chemistry courses, that MgO is magnesia and SrO is strontia and inconsistently enough that CaO is lime. In their ceramic courses they are taught that lime is a calcined material, the major portion of which is calcium oxide or calcium oxide in natural association with a lesser amount of magnesium oxide, capable of slaking with water. This inconsistency and confusion would be eliminated if the chemists would adopt the name of "calcia" for calcium oxide, thereby releasing the term "lime" for the industrial product of the lime industry as defined by the American Society for Testing Materials. It, of course, would logically follow that barium oxide should be called "baria."

The humorous aspect of this suggestion may be emphasized by pointing out that whereas H_2SO_4 is known as the "king of acids," CaO is known as the "queen of bases." The feminine aspect of the word "calcia" is more in keeping with this point of view than is the word "lime" which certainly is not of feminine significance.

Editor's note: See also S. R. Scholes, "Bora," *Bull. Amer. Ceram. Soc.*, **14** [6] 206 (1935), for the suggestion of calling B_2O_3 "bora."

Dean, New York State College of Ceramics
Alfred, New York

J. M. McKINLEY, PRESIDENT OF THE AMERICAN CERAMIC SOCIETY FOR 1935–1936

J. M. McKinley

J. M. McKinley was born in Shire Oaks, Pa., July 29, 1882. His supervised education was obtained in the grade and high schools of Indianapolis and Lebanon, Ind. From 1900 until 1904, the following instruction was received under what Mr. McKinley has termed "unsupervised education": In 1900 and 1901, he received personal instruction under John A. Brashear, Allegheny Observatory and Carnegie Institute, Pittsburgh, embracing mathematics. During this same period he also did extensive work under Karl Kohlkebeck (Julian Kennedy), covering drafting, machine design, strength of materials, structural design, etc., consisting of regular routine of personal instruction. From 1900 through 1904 he studied various courses in international correspondence schools, and during 1914 and 1915 received personal instruction in chemistry under G. G. Pond, Pennsylvania State College.

From 1898 to the present time, including the period of personal instruction, he held the following positions: From 1898 to 1900 he worked as machinist and millwright in Indiana and Pittsburgh; during the latter part of this period (1899–1900), he was employed by the American Steel Hoop Co. as draftsman and worked on construction layout, including some work in minor details of design.

From 1900 to 1904 he was employed by the Clairton Steel Co. (Carnegie Steel Co.), Clairton, Pa., on detail design and field construction, including civil work on construction of buildings, railroads, sewers, and bridges; during the last two years he was superintendent of construction in charge of all divisions of steel-mill and blast-furnace construction.

During 1904 and 1905, he was civil, mining, and service engineer for the Fayette Fire Brick Co. (later United Fire Brick Co.), Uniontown, Pa.

In 1909 he obtained a position with the Crescent Refractories Co., working in civil, mining, and ceramic engineering, including plant design and construction and steady refractories service engineering. In 1929, this company merged with others to form the North American Refractories Co. (Cleveland, Ohio), and from 1914 to the present time, Mr. McKinley has been in full executive charge of work as vice-president of operation and research.

He became a member of the American Ceramic Society in 1918 and was elected a Fellow of the Society in 1931. From 1929 until 1934, Mr. McKinley represented the Refractories Division as Trustee representative; during 1934 he served as Vice-President of the Society, and 1935–1936 as President of the Society. He is a member of the American Society for Testing Materials and also of the American Refractories Institute. In the latter organization he served four years as classification engineer, one year as vice-president, and two years as president.

In a letter to the Editor, Mr. McKinley has made the following interesting statements:

"I have very little comment to add. Under the heading of "Education Unsupervised," I refer to certain personal instruction under Dr. Brashear, Karl Kohlkebeck, and Dr. G. G. Pond. I might have added that I studied commercial and to some extent general law in the same mannr. I did the same thing pretty exhaustively under a well-known certified public accountant in order to prepare myself years ago for the business administrative phase of my work. At one time in the early part of the century, I passed the examinations to enter an engineering school, but I was confronted by such a substantial increase in salary and such a wide extension in authority and experience that I was led to abandon the idea of a college course, whether wisely or not I shall never know.

"I can not refrain from making it plain that I have gone pretty exhaustively into certain subjects, while there are equally important subjects which I have left behind with only a certain amount of superficial study or reading. All my life I have had little or no use for single facts as such. I have had no desire to group facts in a mathematical relationship, but I have always had the philosophy first in my mind, based on some imaginative correlation of facts, and then have proceeded in an effort to check the philosophy mathematically or have it checked. My experience with men over many years leads me to believe that more men fail by having too much knowledge than too little. Vision is destroyed. Perhaps the best expression I can give you is that I classify the engineer in the same category as the musician and poet.

"My hobbies have been rather diversified but have been confined principally to music and of late years more especially to the theory and practice of photography. My greatest hobby, of course, has been my family.

"My temperament is not always serene, but I have had religious convictions of a type too deeply rooted to permit ready acceptance of all of the selfishness and especially the self-centered methods of modern business. I believe the successful men of the forthcoming generation will be those of sound philosophical attainment with social instincts of the more modern and liberal type.

"Above all things, I have been happy in my work during these later years."

1936 ANNUAL CERAMIC MEETING

The Annual Meeting of the American Ceramic Society, to be held in Columbus, Ohio, March 29 to April 4, 1936, promises to be the largest in the history of the Society.

A program including papers on fundamental and practical ceramic subjects is being prepared which will be of great interest to ceramic engineers, technologists, and educators.

Each year the programs of the American Ceramic Society have been growing better, as the interest in the science of ceramics is increasing and as the demands of competition and the public are requiring higher standards of quality. Through increased activity in the fields of production and research during the past few years there should be many interesting and highly informative discussions presented.

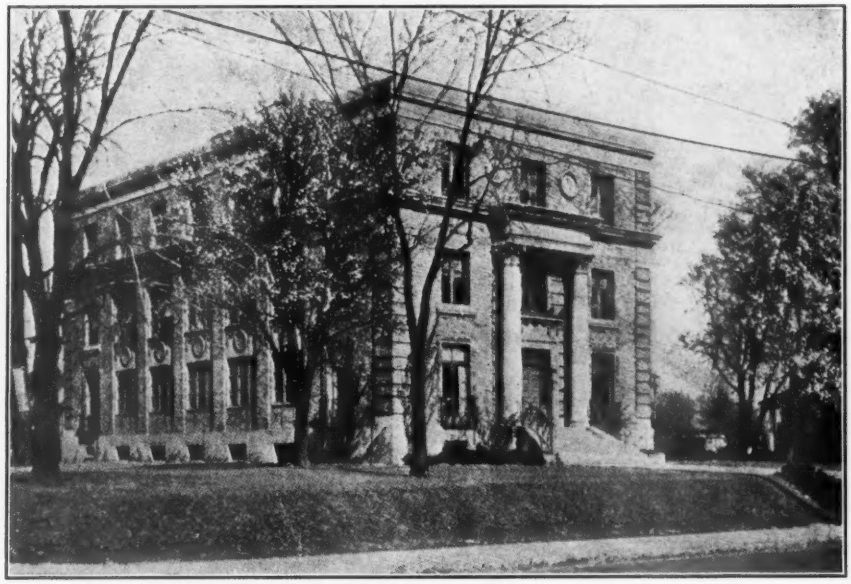
As a meeting site for a ceramic gathering, Columbus is perhaps unsurpassed. It is located in the heart of the ceramic manufacturing world, being surrounded by localities wherein are manufactured chinaware, stoneware, floor tile, drain tile, sewer pipe, paving and building brick, electrical porcelain, refractories, vitreous enameled ware, and glassware.

Only a few miles from Columbus is located the famous Zanesville-Roseville district which has rightfully gained the reputation as a stoneware center of the world through years of production of fine art and utility stoneware. In the city of Columbus are numerous ceramic industries, including the Claycraft Company, one of the country's leading glazed brick manufacturers; Owens-Illinois Glass Company and the Federal Glass Company, large manufacturers of utility and art glassware, respectively. Also located in

Engineering Experiment Station, Ohio State University
Ceramic research under the direction of G. A. Bole is carried on here.

Columbus are several nationally known educational and research institutions of particular interest to ceramists, namely, Ohio State University, Edward Orton, Jr., Ceramic Foundation, and Battelle Memorial Institute.

It was at Ohio State University that Edward Orton, Jr., founded the first ceramic school, which through the years has gained a national reputation as an educational and research organization of the first order under the directorship of A. S. Watts. Also located on the campus of Ohio State University is the Ceramic Art Department, under the direction of A. E. Baggs, which is outstanding as a school of ceramic art. The Engineering Experiment Station of Ohio State University maintains a ceramic research group under



The Edward Orton, Jr., Ceramic Foundation Laboratories and factory for the production of Orton Standard Pyrometric Cones are housed in the building shown herewith.

the direction of G. A. Bole and needs no introduction to the ceramic industry. Through its studies of various ceramic problems many important and lasting contributions have been given to science.

The Edward Orton, Jr., Ceramic Foundation, producers of standard pyrometric cones for measuring heat treatment in ceramic kilns, maintains a research staff busy with research problems concerning pyrometric cones, heat treatment of ceramic materials, and allied subjects.

Battelle Memorial Institute is one of the best equipped research laboratories in the country. Its generous endowment from Gordon Battelle and his mother, Annie Norton Battelle, has made possible provision of ample space and facilities for laboratory and semi-plant research work. The Institute's projects embrace many fields, including ceramics, metallurgy, fuels, and chemistry. The facilities of the Institute are also available to industry under the sponsorship plan and many industries are taking advantage of this to solve their production and development problems.

A visit to any of these educational and research institutions should be of interest to those attending the Meeting and arrangements for this have been made by the Plant Visitation Committee.

The city of Columbus and particularly its ceramic industries and research institutions are delighted to be hosts to the American Ceramic Society on the occasion of its 38th Annual Meeting, March 29 to April 4, 1936.

Battelle Memorial Institute, Columbus, Ohio, organized to serve industry by the practical application of science.

PROPOSED SYMPOSIUM ON BODY AND GLAZE PROPERTIES, WHITE WARES DIVISION, AMERICAN CERAMIC SOCIETY

38th Annual Meeting, March 29 to April 4, Columbus, Ohio

ATTENTION CERAMISTS

THIS IS YOUR OPPORTUNITY AND YOUR DUTY

The following correspondence has developed the proposal of having a symposium on body and glaze properties. You are requested to notify at once V. J. Roehm, Sebring Pottery Company, Sebring, Ohio, that you will participate.

Cause of Crazing

December 26, 1935

To Mrs. Martha B. King:

The mineral mixtures used in the pottery body and glaze when fired in the kiln do not completely form a chemically or even a mineralogically homogeneous mass; neither do the components of iron, steel, or the fusion of any mixture of things other than those that form pure crystals. The clay, ground quartz, and feldspar used in the pottery body undergo chemical and mineral changes and to some extent fuse into a glass (which glass causes partial vitrification and gives the body its strength), but the fired body remains as a mixture of minerals. Even in the fired glaze in which the components are fused completely to a glass, there is a mixture of new compounds which, to considerable extent, can be identified by X-ray methods. Each of these mineral components in the body and in the glaze undergo their individualistic changes in form and size with temperature changes, and in the case of some of these minerals there is no returning to their original volumes when subjected to temperature changes. Furthermore, the amount and character of material dissolved by the glaze from the body varies with the composition of each and with the glost-firing treatment, and the material thus dissolved by the glaze from the body is not diffused equally through the layer of glaze. The glaze when fused on the ware in the glost firing is not the same in composition as when it was applied nor has it uniform composition throughout when fired onto the body. As in glassware, the glaze and the glass that cause vitrification in the body also show in polarized light a varied amount and character of strains.

The harmonizing of the expansion of the body and glaze will not altogether obviate crazing. Crazing is obviated by the employment of those mineral mixtures, the compounding of them and the firing of the ware so there will be the minimum of physical changes and of physical stresses in the finished product. It has been shown that crazing of the glaze will not necessarily be caused even when there is a considerable difference in the expansion of the glaze and of the body when each is submitted to temperature changes.

—Ross C. Purdy

Glaze Fit

January 2, 1936

To Ross C. Purdy:

Answering your valued letter concerning the matter of glaze fit, I am sorry that I gave you the impression as to the minor effect of thermal expansion. I was merely quoting Lehmann and Schulze from their article in *Sprechsaal.*[1]

I agree with you that there are other factors involved in glaze fit such as you refer to, but I would not call the effect of thermal expansion a minor one. We have to allow for that in all of our glaze work and we proceed very much like Stanley Burt did many years ago. I cheerfully grant that matters are quite complex when we deal with the more basic glazes, but any glaze in tension is apt to craze and we try to convert the tension into a slight compression. We do this by lowering the thermal expansion. Heaven knows that there are other things that must be considered just as you say, but we must not underestimate the expansion.

—Albert V. Bleininger,
Newell, W. Va.

Cause of Crazing

January 7, 1936

To. J. T. Robson:

(1) At no time and in nothing that I have written or said has coefficient of expansion been omitted as one of the causes of glaze strains that result in crazing. I have been in opposition to the idea that the effective difference in coefficient of expansion was that of one material superimposed on another. Professor Orton used to illustrate this by referring to the temperature regulators that we so often see in greenhouses, that of two strips of metal which, with rising temperature, would bend and make electric contact due to the difference in the elongation of the two materials by expansion.

(2) The effect of expansion in different portions of the body and of the glaze is not in any one direction, particularly not altogether parallel with the surface of the ware, but is in all directions, *i.e.*, cubical. The expansion, furthermore, is not uniform over the whole surface of the ware nor at different depths of the glaze.

(3) Some people erroneously assume that the compression strains which can be seen in glazes are due to differences in expansion of the glaze and that of the body. These same compression strains are seen in every piece of blown glassware. By annealing, these compression strains are reduced, but it has been learned by experience that if they are entirely eliminated the ware is too fragile. Bottle

[1] H. Lehmann and M.-T. Schulze, "Expansion Behavior of Earthenware Glazes," *Ber. deut. keram. Ges.*, **16** [1] 1–19 (1935); *Ceram. Abs.*, **14** [8] 193 (1935).

makers, for instance, purposely avoid thorough annealing of their ware, and by "thorough" I mean the complete elimination of the compression strains. Yet the glass in the bottle is of the same composition and is apparently quite uniform in its physical makeup throughout the entire thickness of the glass. Is there a difference in coefficient of expansion of the glass on the outside and that on the inside of the bottle?

(4) We have seen advertisements lately telling of toughening plate glass by putting one side of the glass under heavy compression. This is done by heat-treating one side of the glass and rapid cooling. The glass apparently has not been altered in any way as far as casual inspection would reveal, yet under polarized light the heat-treated surface shows heavy compression strains.

(5) We know that the physical characteristics vary radically according to the conditions of their fusion. Alpha-corundum, for instance, can be made in the electric furnace only from bauxite or similar minerals that are practically free from silica and iron. Where either the iron or the silica is present in such large quantities as to require large additions of either silica or iron to wash out the impurities as a ferro-silicon, a considerable portion of the corundum will be converted to the β-corundum. Attempts to produce corundum from clay result in a mixture of α- and β-corundum, the amount of β being almost in direct proportion to the predominance of silica in the clay. The other forms of corundum will result if there are certain impurities in the bauxite. In the same way, the results of fusions vary radically, mineralogically, and physically, according to the materials which have been fused together.

(6) Crazing is not due alone to difference in expansion of the glaze and of the body but to many physical factors of which expansion is one, and this expansion is not in any one given direction.

—Ross C. Purdy

Robson's Reply on Cause of Crazing

January 15, 1936

To Ross C. Purdy:

Replying to your letter, as to the cause of crazing, we have discussed this with Mr. McIntyre, and the following comments have been made:

In paragraph 3, we believe you are correct in that some people erroneously assume that the compression strains which can be seen in glazes are due to differences in expansion of the glaze and that of the body. We do not agree, however, that your simile referring to the compression strains of blown glassware is accurate. Glass-blown articles have numerous strains, but this may be true even with uniform coefficient of expansion throughout the body. Thin sections cool much more rapidly than heavy sections, thereby setting up strains. Even with uniform coefficient of expansion to avoid strains the entire article must be blown and cooled under uniform conditions of thickness, time, and temperature, which, of course, is a physical impossibility even for a flat piece of glass. In other words, the coefficient of expansion in the glass can easily be the same and yet the glass can show all the phenomena of strain due to uneven cooling and solidification.

In paragraph 4 of your letter, the same is true for heat-tempered glass. The outside is rapidly chilled by quenching; the inside remains molten, while the outside is solid. This naturally sets up compression and tension strains in the body, but does not change the actual coefficient of expansion.

In paragraph 5, you state that there are today in our records some five or six different sets of values for coefficient of expansion, each of which has been checked and rechecked, and that these different sets of values do not agree. This is true. However, work done here in our laboratory on the coefficient of expansion of enamels shows that the factors of Mayer and Havas for the different oxides hold very well for the very narrow temperature range in which they were determined, *i.e.*, from 0° to 100°C. We know from work already published and work done here in the laboratory on coefficient of expansion that these values vary considerably above 100°C, so that the values obtained from the different tables you speak of (due to the fact that they were determined at low temperatures and since the coefficient of expansion is not the same at elevated temperatures, but varies at different temperatures above 100°C) make it impossible for us to calculate accurately the difference in coefficient of expansion of different glazes at temperatures higher than 100°C.

In paragraph 6, you say that crazing is not due to difference in expansion of the glaze and of the body, but is due to many physical factors, of which expansion is one, and this expansion is not in any one given direction. Certainly, the expansion is not in any one direction. Crazing is due to many physical factors, of which expansion is one, but the difference in coefficient of expansion between the glaze and the body may also be a factor. Certainly there must be strains set up in a glaze at the point where it begins to solidify and these will be effected by the shrinkage of the body itself. In other words, if the coefficient of expansion of the glaze around 1000° to 1200°F is higher than one body and in another case is lower than a different body, then there is difference in the strains set up in this glaze on the two different bodies due to the body itself, which we admit is only one of many strains set up in the glaze. We likewise know that at this temperature, due to a quartz transformation, we must be careful in firing to prevent strains or dunts being set up in the body (the dunts can be likened to crazing of the glaze). Most certainly with the tremendous strains set up in the body at this temperature, there must be strains set up in the glaze covering the body. We feel that the main reason that the coefficient of expansion values can not be used with any success in determining the crazing resistance of different glazes is primarily due to the variation in the coefficient of expansion above those temperatures listed in published tables. If we had these figures for temperature ranges from room temperature to solidification points of the glaze, then we might have values that would give us some bearing as to the crazing resistance of the glazes. At least, they would give us the information regarding the strains set up insofar as coefficient of expansion is concerned, which is, as we have always stated, only one of several causes of crazing, but which we believe to be a vital cause.

—J. T. Robson,
Cleveland, Ohio

Symposium on Glaze Fit

January 10, 1936

To V. J. Roehm:

I feel a "verse" coming, not wholly unexpected of course, after the recent exchange of views on glaze fit. This verse (in prose) is a proposal that the White Wares Division have a symposium on this subject. During the past year, the British and European ceramists have come to the same conclusion as Seger and as was so emphatically brought out in 1913 by myself and coworkers that the question of glaze fit is not simply a matter of equal coefficient of expansion of the body and of the glaze. This is not a new discovery. He who has believed and taught otherwise has been blind to the evidence.

It was shown by Hall[1] that the effect of oxide additions on the coefficient of expansion of a glaze could not be expressed by a certain factor should the composition of the glaze vary greatly. English and Turner[2] made the statement that their factors did not have universal application. We have, in our own publications, plenty of evidence that coefficient expansion differences of body and glaze do not alone determine glaze fit and these domestic findings and opinions, even those published a quarter century ago, are impressive findings.

Every attempt to alter the coefficient of expansion of glazes by oxide variations according to any one of the set of expansion factors has failed largely because a given oxide enters into various combinations with other oxides, depending upon the mixture used.

We have many studies on glaze fit published in late years in the *Journal*. If these were carefully read, one would conclude that there are many reasons for crazing, even for delayed crazing. Some of these studies from *The Journal of the American Ceramic Society* are as follows:

(1) Ira E. Sproat, "Effect of Heat Treatment and Composition of Semiporcelain Bodies on Crazing," **6,** 510 (1923).
(2) G. E. Merritt and C. G. Peters, "Interferometer Measurements of the Thermal Dilatation of Glazed Ware," **9,** 327 (1926).
(3) H. G. Schurecht, "Methods of Testing Crazing of Glazes Caused by Increases of Ceramic Bodies," **11,** 271 (1928).
(4) E. P. Wright, "Study of Absorption of Two Earthenware Bodies and Their Resistance to Crazing in the Steam Test," **12,** 118 (1929).
(5) H. G. Schurecht and G. R. Pole, "Effect of Water in Expanding Ceramic Bodies of Different Compositions," **12,** 596 (1929).
(6) L. D. Fetterolf and C. W. Parmelee, "Effects of Soda, Barium, and Zinc on the Elasticity and Thermal Expansion Coefficients of Glass," **12,** 193 (1929).
(7) F. P. Hall, "Influence of Chemical Composition on Physical Properties of Glazes," **13,** 182 (1930).
(8) H. G. Schurecht and G. R. Pole, "Measuring Strains between Glazes and Ceramic Bodies," **13,** 369 (1930). (This gives the well-known "ring test".)
(9) R. G. Mills, "Use of Autoclave in Testing Ceramic Products for Resistance to Crazing," **13,** 903 (1930).
(10) J. O. Everhart, "Some Simulative Service Tests for Glazed Building Materials," **13,** 404 (1930). (Note: "Differential expansion of body and glaze" in conclusions on p. 408 is not coefficient of expansion.)
(11) H. H. Holscher, "Effects of Autoclave Treatments on Ceramic Bodies and Clays," **14,** 207 (1931).
(12) H. G. Schurecht and G. R. Pole, "Moisture Expansion of Glazes and Other Ceramic Finishes," **14,** 313 (1931).
(13) H. G. Schurecht and D. H. Fuller, "Effects of Thermal Shock in Causing Crazing," **14,** 565 (1931).
(14) H. G. Schurecht and G. R. Pole, "Some Special Types of Crazing," **15,** 632 (1932).

The influence of various materials on the growth in volume of the body is one of the causes of delayed crazing; and furthermore, it has a bearing on the durability of the ware. It has been observed that vitrified sewer pipe on altogether too many yards will have their strengths fall below minimum standard by weathering. We learned fifteen years ago that "vitrified" grinding wheels then made deteriorated with age. This subject is important to all producers of clayware, vitrified and nonvitrified.

—Ross C. Purdy

Toughened Glass

January 9, 1936

To J. T. Littleton, Corning, N.Y., F. W. Preston, Butler, Pa., and James Bailey, Hamburg, N.Y.:

On reading the papers by Bailey[3] and Littleton and Preston,[4] I am impressed with the thought that these same considerations would be of value to the manufacturers of clay tableware.

There are those who claim that to produce a noncrazing glaze on semivitreous and vitreous china the glaze must be under compression. By this I assume that the glaze should have a lower coefficient of expansion and contraction than that of the body. The time-honored theory for the cause of crazing of glaze is that it could not expand with the body and would not have the strength to withstand this rupturing stress. Glazed clayware will craze quite often after it has stood in storage or on pantry shelves and not suffer any great temperature variation. Some glazed ware crazes when submitted to autoclave treatment with moderate pressure and temperature. This delayed crazing has been assumed by some to be due to a growth in volume of the body of the ware either permanently or temporarily, owing to the water which it adsorbs and, in some cases possibly, hydrates.

There are many of us who believe that crazing is due to various sorts of tensions, among them expansion strains, but that whether or not the glaze will craze is not so dependent upon the difference in the coefficient of expansion of the body and of that of the glaze.

Some of us have made expansion measurements on glazes and on the body, have applied the same glaze over a variety of bodies represented by points on the tri-

[1] F. P. Hall, "Influence of Chemical Composition on Physical Properties of Glazes," *Jour. Amer. Ceram. Soc.*, **13** [3] 182–99 (1930); p. 198.
[2] S. English and W. E. S. Turner, "Relationship between Chemical Composition and Thermal Expansion of Glasses," *ibid.*, **10** [8] 551–91 (1927).

[3] James Bailey, "Strength of Glass as Affected by Casing," *Jour. Amer. Ceram. Soc.*, **14** [11] 811 (1931).
[4] J. T. Littleton and F. W. Preston, "Theory of the Strength of Thermally Toughened Glass," *Jour. Soc. Glass Tech.*, **13,** 336 (1930).

axial diagram, and have found that the same glaze fitted equally as well on bodies of high and low expansion.

Another observation is that most any glaze, whether it is prone to craze or to fit a given body, will show compression strains.

Furthermore it has been found that the glaze which results from fusion in the glost fire is not the same composition as that which was applied to the ware; it has been altered in composition by material dissolved from the body. This dissolving from the body of certain minerals is a progressive reaction, the amount dissolved being dependent upon the composition of the body and also of the glaze and the length of heat treatment. The material dissolved by the glaze is not uniformly disseminated through the glaze, and since the body is made of comminuted mineral particles and since each mineral in the body is not equally soluble in the glaze, the resultant glaze on the finished ware is not homogeneous.

There are two questions I want to ask:

(1) In toughened glass, what is known about the difference in coefficient of expansion of the fire-treated surface and that of the untreated portion? For instance, what is the difference in the coefficient of expansion of the outside and the inside of an unannealed blown glass article which shows the outside surface to be under compression?

(2) My second question is regarding the reason for glazes that have been fused on to clayware in tunnel kilns and given a thorough annealing showing compression strains. Is this due to the glaze having a lower expansion than that of the body or is it more probably due to the fact that it is wholly unhomogeneous in composition and constitution, not only over a given area but throughout the glaze thickness?

—Ross C. Purdy

January 16, 1936

To Ross C. Purdy:

The two questions which you propounded in your letter of January 9, touch one of the most difficult branches of experimentation and no doubt you will collect a wide assortment of answers to them.

Question No. 1

A glass suddenly chilled from a temperature above its softening point tends, due to its elastico-viscosity, to maintain the characteristics of its high-temperature state, and its coefficient of expansion is somewhat greater in the rapidly chilled condition. The difference is so small, however, that the strain in the outer layers can not be attributed to a change in the coefficient of expansion. Further, all types of glass may be thermally toughened to a considerable extent whereas some of them show very little difference in the expansion coefficient whether or not they have been suddenly chilled, cooled in air, or carefully annealed. The phenomenon is somewhat similar to the depression in the zero point of some thermometer glasses and to other mechanical changes which take place in the region of room temperature. The effect of strain upon the coefficient of expansion is discussed by Hovestadt.[5]

[5] Hovestadt, Jena Glass, pp. 217–22 (Everett translation).

The stresses shown in toughened glass or in ordinary unannealed glasses are so great that they must be attributed to the unequal rate of cooling as admirably set forth by Adams and Williamson.[6]

While there may be arguments regarding the diffusivity coefficient used in the above article and hence the time factor, my personal opinion is that thermal toughening is adequately explained by a simple theory of the unequal rate of cooling between the outer and inner layers of the glass.

Question No. 2

The second question, regarding stresses in glazes, is very much more complicated. In this case, all of the factors are transient in nature. There can be no question that the composition of a glaze changes from the outer surface to the interface and that the interface gradually changes into the composition of the body. The glaze, in many cases, is not a true homogeneous glass at any time. While heating up the kiln, the glaze is gradually sintering together and becoming more glassy, but at the same time material from the body is being dissolved into the glass, and crystallization at the interface soon begins. If the ware is held hot long enough, the glaze may be entirely absorbed into the body.

If the glaze is separated from its body by grinding away the body, the glaze is almost always found to be full of very small crystals around which strains can be seen in a petrographic microscope. These crystals must have an effect upon the average coefficient of expansion and fit of the glaze.

The gradual transition from the glaze to the body undoubtedly helps hold the glaze firmly in place enabling it to withstand more severe strains than it otherwise would. The thickness is also a factor in the resistance of the glaze to crazing and shivering.

Notwithstanding all of these facts, it has been demonstrated[7] that a glaze having a higher coefficient of expansion than the body, and hence left in tension when cool, will eventually craze. The glaze must be under a slight medium compression to be commercially satisfactory as found by these and other investigators.

That the coefficient of expansion of the glaze as it actually exists on the body is not the same as that of the glass made by melting the same composition is shown by Merritt and Peters.[8] They also show that it is necessary for a glaze and body to have nearly the same expansion and contraction throughout the entire range from room temperature to the annealing point of the glaze if crazing is to be prevented.

The development of glaze cracks a long time after manufacture may be due to (1) growth in the body which puts the glaze in tension; this can not happen if all of body is tightly glazed; (2) small residual strains in the

[6] L. H. Adams and E. D. Williamson, *Jour. Frank. Inst.*, **190**, 597–631, 835–70 (1920).

[7] H. E. Davis and R. L. Lueders, "Simplification of the Ring Method for Determining Glaze Stresses," *Jour. Amer. Ceram. Soc.*, **15** [1] 34 (1932).

[8] G. E. Merritt and C. G. Peters, "Interferometer Measurements of the Thermal Dilatation of Glazed Ware," *ibid.*, **9** [6] 327 (1926).

glaze which are not sufficient to crack the glaze until it has been weakened by (*a*) scratching, (*b*) weathering, and (*c*) time. As is well known, glass will rupture if left under load for a sufficiently long time at strains of about half of that required to break it in a short time test such as is usually made in a laboratory.

You have set down the problem of crazing in a condensed and yet clear manner. With all of the different types of bodies and kinds of glazes, the White Wares Division will have plenty of room to develop an interesting discussion.

Personally, I feel that problems involving breakage are primarily of a mechanical nature, but the reasons why there are mechanical stresses present and why these cause breakage may involve mechanical injury, decrease of strength with time, decrease of strength due to chemical disintegration, such as weathering or volume changes of a chemical nature and many other factors.

—James Bailey,
Hamburg, N. Y.

January 16, 1936

To Ross C. Purdy:

This concerns your proposed Symposium before the White Wares Division on Body and Glaze Properties.

I am very much interested in this Symposium and regret that as yet we have no experimental data directly applicable to it, although we are measuring rate of flow of cone bodies under load. As I see the problem, proper heat treatment of porcelain (which is essentially a suspension of tiny crystalline mullite particles in a viscous glass) should be based on the same principles as in the glass industry. Referring to the Penn State-Pittsburgh Section Meeting, October 20–21, 1934, I find that there are at least three aspects to the heat treatment of glass. They are as follows: (1) correct annealing procedure based on a knowledge of "softening temperatures" and the Adams and Williamson equation (discussed by Littleton); (2) crystal nuclei formation and crystal growth in opal glasses (discussed by Blau); and (3) improvement of strength by quick chilling, as shown in electrical porcelain (by Fritz).

In addition to these viewpoints, I should mention Sosman's comments on reversible and irreversible (or slowly reversible) effects in glass resulting from thermal and mechanical treatments.

In my opinion, the White Wares Division would do well to obtain such speakers as these. It is immediately clear that what is needed is a quantitative attack on the properties of the whiteware glasses by the most refined optical, electrical, and physical methods at our disposal, in principle, exactly those methods which have proved so fruitful in the study of commercial glasses.

—Nelson W. Taylor,
State College, Pa.

January 11, 1936

To Ross C. Purdy:

Your letter contains a lot of interesting information, and the statements made are more interesting than the questions asked at the end.

As to question (1), in toughened glass, the outside of which is in compression and the inside in tension, there is, apart from these mechanical strains, a deficiency of density in all parts of the glass. This deficiency is greatest on the compressed surface, I believe, after the surface has been broken up into small particles, but in any case, the difference of density between the inside and the outside is small in comparison with the difference between either of these figures and the density of thoroughly annealed glass. I take it that the deficiency of density is a fair indicator of the constitution of the glass and of the departure of the glass from a normal coefficient of expansion. In other words, all parts of the glass ought to show an abnormal expansion, but I would not expect the difference between the inside and the outside layers to be very great.

As to the question (2), I do not think I can answer this until I know by what means the alleged compressive condition of the glaze was determined. The question as to whether the glaze is cracking itself or whether the body of the ware is cracking the glaze ought to be capable of being settled by observing how deeply the cracks go. If the cracks go completely through the glaze, then the clayware is responsible; if they stop short of this point, the chances are that the glaze is cracking itself.

I do not feel that a theoretical discussion of the subject would be of any particular interest, and the experimental evidence ought be sufficient to settle the matter.

—F. W. Preston,
Butler, Pa.

January 17, 1936

To Ross C. Purdy:

I have been giving some thought to your letter of January 9 regarding porcelain glazes. You asked two definite questions:

(1) First, as to the difference in expansion between the surface of the glass and the underbody glass in quickly chilled glass. Up until the softening point of the glass is obtained, there is very little difference in expansion coefficient.

(2) If a glaze be under compression that means undoubtedly that as far as its total body is concerned it has shrunk less than the underbody clay. The fact that the glaze is nonhomogeneous, particularly at the glass porcelain interface, may mean that this portion of the glaze is under compression while the actual air surface of the glaze might be under tension. In that case, you have something equivalent to a triple-layer material: porcelain, porcelain-glass mixture, and glass. If a glaze be under compression, it will stand sudden cooling, etc., better than a glaze under tension, but it would not be as resistant to sudden heating as a glaze which was under tension or neutral.

I have an idea that the difficulty in interpreting observations into one consistent story referred to by you is due to the fact that the observations are in error at some vital point.

—J. T. Littleton,
Corning, N. Y.

REASONS FOR 1936 ANNUAL MEETING IN COLUMBUS, OHIO

In the past several years, it has been the custom of the community which is acting as host to the American Ceramic Society for its Annual Meeting to raise money for entertainment of the visiting guests. This sum has varied according to the number of ceramic manufacturers in the surrounding district and according to the type of entertainment planned. The Board of Trustees of the Society has been alarmed at the increasing burden placed upon the acting hosts and has felt that invitations into centers of ceramic importance might be withheld because of the local expense involved.

The Meeting to be held in Columbus, Ohio, March 29 to April 4, 1936, is to be operated on an "economy plan," and Columbus was chosen purposely as a test place for this plan. The following letter from C. C. Treischel voices the question of a number of our members as to why Columbus was chosen, when it was known from the first that there was no single hotel adequate to handle the entire series of sessions. The disadvantage of having the Division Meetings split between the Deshler-Wallick Hotel and the Neil House will be counterbalanced by the advantage of the opportunity of showing that an excellent meeting may be held at less cost than any in recent years. Mr. Treischel's letter is, in part, as follows:

Hayes Hall, Ohio State University
The Ceramic Art Division of the Department of Fine Arts is located in this building. Arthur E. Baggs, Professor of Ceramic Art, has charge of this division.

Lord Hall, Ohio State University
The Department of Ceramic Engineering under the direction of Arthur S. Watts is located here.

"Ever since the first notice in *The Bulletin*, indicating that the Columbus Meeting would be split between two hotels, I have been hearing a lot of criticism of the selection of Columbus for our Annual Meeting. I have personally criticized the selection because I am against holding our Meetings in different hotels or away from the headquarters.

A few days ago I was talking with Jesse Littleton and in a casual way he stated that Columbus had been selected because, by holding the Meeting there, the Society would save a tidy sum of money. To me, this changes things entirely.

Knowing a little of the financial status of the Society, I heartily applaud the decision of the Board. I would personally put up with a lot of inconvenience to help save money; in fact, under the conditions, I would endorse holding all future meetings at Columbus until such time as the Society can really afford to hold meetings elsewhere.

There is, however, a large group of members unacquainted with the reason for the selection of Columbus. This group feels as I do about 'split meetings.' If you could let them know, through the medium of *The Bulletin* the facts about this Meeting, I'm sure that most of them would feel as I do now."

WILLIAM J. McCAUGHEY IS FOURTH EDWARD ORTON, JR., FELLOW LECTURER

W. J. McCaughey of Ohio State University is an interesting figure to ceramists. It is particularly fortunate that he is the choice as the Edward Orton, Jr., Fellow Lecturer at the Annual Meeting of the American Ceramic Society this year in Columbus. Dr. McCaughey is a mineralogist and, as such, he has studied ceramic products for many years at that very strategic point, namely, at the point of their behavior in service. Aided by the petrographic microscope, the X-ray, and a varied experience combined with natural talent for such work, he has followed those very elusive but extremely important changes that take place under the influence of time and temperature.

He has traced these changes from the raw clay state all the way through the manufacture of clay products, their service period, and on until their usefulness is over. And he is even more interested in them then, for these veterans from the firing line have many important secrets to reveal to one of Dr. McCaughey's ability; pointing a microscope at them or bombarding them with X-rays, he compels them to answer questions such as why they gave good service or why they failed.

The importance of thermochemical theories is becoming increasingly recognized in ceramics. Dr. McCaughey not only is past master of thermochemical theories but he is constantly aiding in their development. On the other hand, he has an unusual amount of practical experience

to back his theories. This experience has come not only through his own researches but also from his constant contact with manufacturers of ceramic ware on one hand and with the consumers of them on the other. Executives of porcelain, refractory, and other types of ceramic plants are constantly bringing their problems to him. Open-hearth and blast-furnace experts call on him for advice almost daily. His many friends, among them many of his own pupils, in industrial plants keep him informed of developments and supply him with materials for study.

In addition to his varied, intimate, and active experience with many of those problems that are greatly troubling ceramic men right now, Dr. McCaughey has preëminent ability to express his knowledge in an interesting way. His pupils bear enthusiastic witness to this. "Best lecturer on the campus" is a commonly expressed opinion. He has the natural ability to teach and he loves to do so. Because of this he has consistently refused offers of better positions in industry and he subordinates industrial consulting to class instruction. The sacrifices he has made are in part repaid by the esteem in which he is held by his many pupils who have names for themselves in various lines, as well as by the nationwide respect in which his ability is held and by the honor bestowed upon him as the Edward Orton, Jr., Fellow Lecturer for 1936.

When Dr. McCaughey comes to the platform to do honor to one of the greatest figures of ceramic history, Edward Orton, Jr., one may be assured of three things: First, what he will say comes from a world of practical experience; second, it will bear on points that deeply concern ceramists at this very time; and, third, it will be presented in a manner that will keep everyone's interest at a high pitch every moment.

LAWRENCE SAINT'S WORK IN STAINED GLASS

The following letter, written by Lawrence Saint, December 19, 1935, outlines this artist's point of view on the creation of stained glass windows. Mr. Saint will address a general session of the American Ceramic Society during the Annual Meeting at Columbus, Ohio. His subject is "Is Stained Glass a Lost Art?"

"Washington Cathedral, after having conducted a Department of Stained Glass, of which I have been Director here in Huntingdon Valley for seven and one-half years, has finally decided to discontinue the department after December 30, 1935. The Very Rev. G. C. F. Bratenahl, Dean of Washington Cathedral, has written, 'I am more sorry than words can express that our present situation seems to make this action on our part unavoidable. . . . This termination of the Department of Stained Glass at Huntingdon Valley will not interfere with any arrangements regarding your undertaking further stained glass windows, providing the Chapter so decides, and providing it is agreeable to you.'

"The Cathedral's attitude in terminating the Stained Glass Department has been most gracious and generous to me. Dr. Bratenahl's letter says in effect that the Chapter has resolved to hand over to me their entire investment here, March 30, 1936, in view of my 'devotion to Washington Cathedral, assiduous work, and continuous development in the windows.'

"I plan definitely to adhere to my ideals to make windows of the highest possible character: from the spiritual standpoint to glorify my Blessed Lord, and from the craftsman's standpoint *to follow the standards of the Middle Ages in craftsmanship excellence and endurance.* Also *I desire definitely to restrict my work to biblical subjects, more especially to those in the New Testament,* as I have been permitted to do for the last seventeen years.

"I am definitely *determined to make my own glass,* without which my art would suffer serious loss. My oldest son, Sam, has taken up the work of the glassmaking. I *have made about fifteen hundred glass formulas* and have spent years in learning how to use the medieval type of glass, which the chemist's report shows is 'very slightly turbid,' resulting from phosphoric anhydride (giving it a body), making it different in character from ordinary transparent colored glass.

"*I make special glass, close to medieval shades,* to suit my *original designs* when the existing stock is lacking in range, even determining the irregularity of thickness for definite windows. This is in general contrast to the usual procedure, where carrying out the design is limited to the glass stock at hand. Imagine a picture painted by an artist who used only colors as he squeezed them from a tube, without mixing them together to achieve harmony and lovely tone.

"I *make all my own paint also,* which I worked out at Bryn Athyn. It has a warmth of tone such as is not to be had in purchasable paint, as far as I know.

"We have made glassware during the years, particularly for Washington Cathedral, and I am contemplating extending this work in order automatically to be able at the same time to build up our glass stock without too much financial investment.

"I pay grateful tribute to the blessing of my Lord on my stained glass handiwork. *For seventeen years I have had constant occupation with almost unlimited opportunities for the practice of my art.*

"My ideals for the future will continue to be the West Lancets of Chartres Cathedral, the Poitiers "Crucifixion Window," and the choir clerestory windows of León Cathedral, Spain. I definitely desire to make rich, colorful, light-admitting windows in what may be called a middle register, giving reverential glory with a feeling of warmth and joyousness.

"You may know that I *have designed thirteen windows now in Washington Cathedral.* I shall for some time be occupied with the two Memorial windows for the Cathedral given by Mrs. William T. Hildrup, Jr."

CONTINUE YOUR GRADUATE WORK IN CERAMICS—ATTEND THE 1936 ANNUAL MEETING IN COLUMBUS, OHIO

ART DIVISION SEEKS NAMES OF PROSPECTIVE MEMBERS

The Art Division of the Society is on the way to coming into its own. Considerable progress has been made during the current year. We are in the midst of a campaign to secure a minimum of two thousand names of persons and organizations who are interested in some phase of ceramic art. During this first year we have nearly approached the half-way mark.

The writer, who has been acting as Chairman of the Membership Committee, wishes to thank the various members of his Committee of thirty persons scattered throughout the country who have given splendid help and support. Furthermore, he wishes to make an appeal to these and others who are in a position to send in the names of persons, who might be interested in the work of this Division, in order that they may receive from time to time from the Secretary's office important announcements concerning the Division's activities.

As a Division, we are particularly interested in securing the names of students, teachers, studio potters, dealers, and any institutions, organizations, or individuals who are interested in the further development of a high type of ceramic art in this country.

Anyone who knows of interested persons should send their names to C. C. Engle, c/o of United Clay Mines Corp., Trenton, N. J. —C. C. Engle, *Chairman*, Membership Committee, Art Division

NEW MEMBERS AND ROSTER CHANGES

Personal

Athy, Lyman C., 5242 Audubon, Detroit, Mich.; supt. of manufacturing, Plumbing Division, Briggs Manufacturing Co.

Bahnsen, Monroe J., 1254 Cook Ave., Lakewood, Ohio; Ferro Enamel Corp., Cleveland.

Boyd, John E., Box 52, Spruce Pine, N. C.; chief chemist, Tennessee Mineral Products Corp.

Clarke, William L., 1621 Cleveland Ave., Niagara Falls, N. Y.; ceramic technologist, Carborundum Co.

Cummins, Arthur B., 515 7th St., Plainfield, N. J.; research engineer, Johns-Manville Corp., Manville.

Curll, Daniel B., Jr., 417 Lincoln Court, Overbrook, Pa.; chemist, Philadelphia Quartz Co., Philadelphia.

Dean, Harvey N., 59 E. Van Buren St., Chicago, Ill.; North American Refractories Co.

Faust, George T., Rutgers University, New Brunswick, N. J.; assistant professor of ceramics.

Ford, George E., 50 Church St., New York, N. Y.; vice-president, A. P. Green Fire Brick Co.

Gerdes, Paul E., 12065 Edgewater Drive, Lakewood, Ohio; research ceramist, Ferro Enamel Corp., Cleveland.

Goodwin, Robert K., Redfield, Iowa; treasurer, Redfield Brick & Tile Co.

Hallowell, Rowena, Clay Craft Studio, 14 Fenwick Rd., Winchester, Mass.

Judd, Archie C., P. O. Box 556, Portsmouth, Ohio; vice-president and secretary, Portsmouth Clay Products Co.

MacFarlane, John L., 2420 Elizabeth St., Pueblo, Colorado; Standard Fire Brick Co.

McCarthy, F., 100 E. Oakland Ave., Columbus, Ohio; foundry engineer, The Ironton Fire Brick Co., Ironton, Ohio.

McElroy, William D., 3101 Passyunk Ave., Philadelphia, Pa.; manager, physical laboratory, United Gas Improvement Co.

Merritt, Glenn W., Bowerston, Ohio; general manager, The Mining Safety Device Co.

Schmitz, F. M., 100 E. Rees St., Fond du Lac, Wis.

Steele, George A., 2116 W. Second St., Dayton, Ohio; laboratory assistant, Simonds Worden White Co.

Warrick, Earl L., 309 Ridgewood Ave., West View, Pittsburgh, Pa.; assistant, Macbeth-Evans Glass Co. Fellowship, Mellon Institute.

Whitesell, Robert J., 5023 Akron St., Philadelphia, Pa.; ceramic engineer, Röhm & Haas Co.

Student

Charnes, Abe, University of Illinois.

Dammann, Arthur, North Carolina State College.

Hurst, Thomas L., North Carolina State College.

Martin, Allan E., Pennsylvania State College.

Munro, R. Archibald, Pennsylvania State College.

Newcomb, Rexford, Jr., University of Illinois.

Porter, Allen K., University of Illinois.

MEMBERSHIP WORKERS' RECORD

Personal

C. E. Bales	1	J. M. McKinley	1
G. H. Brown	1	D. A. Moulton	2
B. C. Burgess	1	C. W. Parmelee	1
J. D. Carter	1	H. G. Wolfram	1
R. J. Clark	1	Office	4
H. T. Coss	1	**Student**	
Donald Hagar	1	A. I. Andrews	2
R. A. Heindl	1	A. F. Greaves-Walker	2
W. T. Kay	1	C. W. Parmelee	1
R. R. McGregor	1	N. W. Taylor	1
G. H. McIntyre	2	F. J. Williams	1
		Grand Total	**28**

ROSTER CHANGES DURING JANUARY*

Personal

Branham, Ivan B., 2071 Garfias Drive, Altadena, Calif. (Los Angeles, Calif.)

Ellis-Anwyl, R. H., Waskom, Texas. (Hope, Ark.)

Grout, John R., Jr., Topliff Hotel, Spruce Pine, N. C. (Norwood, N. C.)

Long, R. N., Charles Taylor Sons Co., Taylor, Ky. (Portsmouth, Ohio)

Nordal, Johannes G., Theodore, Sask., Canada. (Saskatoon, Sask.)

Schwendler, Richard H., Jackson St., Mentor, Ohio. (Cleveland Heights, Ohio)

Shaw, J. B., 1373 Rittenhouse St., Washington, D. C., (Harrisburg, Pa.)

Smith, Roy G., Forth Worth Club, Fort Worth, Texas. (Houston, Texas)

Waggoner, Jack H., 6625 Northumberland St., Pittsburgh 17, Pa. (Mellon Institute, Pittsburgh, Pa.)

Weis, J. H., Oxford Mining & Milling Co., West Paris, Maine. (New York, N. Y.)

Williams, Francis J., Mellon Institute, Pittsburgh, Pa. (State College, Pa.)

* Address in parentheses is the old address.

LOCAL SECTION NEWS

Baltimore-Washington Hears N. W. Taylor

The winter meeting of the Baltimore-Washington Section of the Society was held in Baltimore on January 18. Nelson W. Taylor, Head of the Department of Ceramic Engineering, Pennsylvania State College, as the speaker of the evening, gave an illustrated talk on "Chemical Reactions in the Solid State." A round-table discussion of the subject followed the talk.

C. H. Hahner, Washington, D. C., was appointed Vice-Chairman to fill the unexpired term of S. M. Shelton, who resigned.

The Section plans to hold a meeting in March and another in May.

—G. H. SPENCER-STRONG, *Secretary-Treasurer*

Central Ohio Section Holds Election

At a meeting of the Central Ohio Section held in Columbus, Ohio, February 3, 1936, the following officers for the year were elected:

Chairman: Chester R. Austin, Battelle Memorial Institute, Columbus, Ohio.

Secretary-Treasurer: Myril C. Shaw, Edward Orton, Jr., Ceramic Foundation, Columbus, Ohio.

Councilor: John L. Carruthers, Dept. of Ceramic Engineering, Ohio State University, Columbus, Ohio.

—M. C. S.

Michigan-Northwestern Ohio Section Elects Officers

Twenty-eight members of the Michigan-Northwestern Ohio Section of the American Ceramic Society attended a business meeting at Detroit, Mich., January 17, 1936. Officers elected for 1936 are as follows:

Chairman: Macon Trabue, Mt. Clemens Pottery Co., Mt. Clemens, Mich.

Vice-Chairman: Thomas Place, Mt. Clemens Pottery Co., Mt. Clemens, Mich.

Secretary-Treasurer: Karl Schwartzwalder, A C Spark Plug Co., Flint, Mich.

Councilor: Probert Dager, Champion Spark Plug Co., Detroit, Mich.

After the business meeting three reels of pictures secured from The General Electric Company of Chicago were shown. One dealt with "The Potters Wheel" and the other two with "Electric Heat in Industry."

—MACON TRABUE, *Chairman*

Pittsburgh Section Elects Officers

Forty-five members attended the January 14 meeting and annual election of officers of this Section. The new officers for 1936–1937 are as follows:

Chairman: H. B. DuBois, Consolidated Feldspar Corp., East Liverpool, Ohio.

Vice-Chairman: E. C. Petrie, Mellon Institute of Industrial Research, Pittsburgh, Pa.

Secretary: Dwight Bennett, Mellon Institute of Industrial Research.

Treasurer: W. C. Rueckel, Koppers Construction Co., Pittsburgh, Pa.

Councilor: R. E. Birch, Harbison-Walker Refractories Co., Pittsburgh, Pa.

Fred Sauereisen was elected chairman of the Pittsburgh Clay Workers Club.

F. O. Anderegg, the speaker of the evening, gave an illustrated talk on "Some Ceramic Problems in the Building Industry."

—EARL C. PETRIE, *Vice-Chairman*

R. B. Sosman to Address Pittsburgh Section

Robert B. Sosman, United States Steel Corp., Research Laboratory, Kearny, N. J., who is nominee for office of vice-president of the American Ceramic Society for 1936–1937, will address the Pittsburgh Section of the Society, February 25, at Mellon Institute, Pittsburgh, Pa.

Dr. Sosman's subject is "Pyrometric Cones and the Measurement of High Temperatures."—R. E. B.

STUDENT BRANCH NEWS

Missouri School of Mines and Metallurgy

The custom of an annual Orton Society (Student Branch of the American Ceramic Society at Rolla) banquet commemorating the birthday of General Edward Orton, Jr., which was established three years ago on this campus, was continued this year on October 8, by a luncheon at which C. M. Dodd entertained the eleven students registered in the Ceramic Department.

The same afternoon, the department was honored by a visit from Ross C. Purdy, General Secretary of the American Ceramic Society.

On November 4, the department was again fortunate to receive as a visitor J. M. McKinley, President of the American Ceramic Society. Mr. McKinley talked to the student group on the subject, "Education Is a Tool—Learn to Use It."

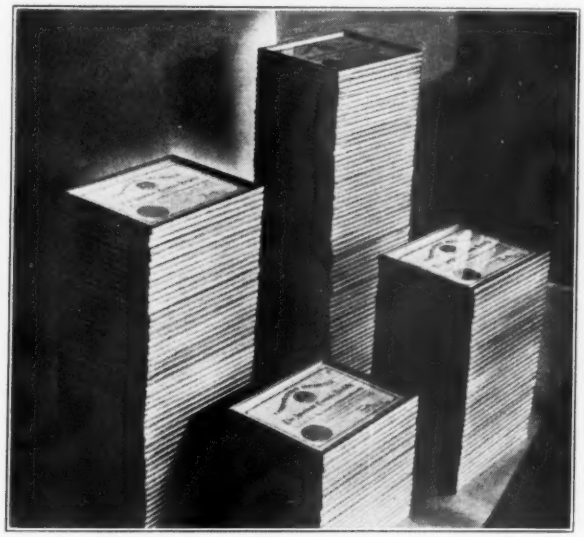
The future program of the Orton Society for this year will depend upon what industrial pictures are available from the Bureau of Mines on the particular dates when the meetings are held. The officers of the Society this semester are Paul C. Branstetter, *President;* A. J. Hoener, *Vice-President;* and Stuart Dodds, *Secretary-Treasurer.*—S. D.

NECROLOGY

John E. Hutchinson

Mr. John E. Hutchinson, Pittsburgh manager of the Pennsylvania Salt Manufacturing Co., Pittsburgh, Pa., died on November 9, 1935. Mr. Hutchinson left Pittsburgh for a vacation in Florida on November 2. At Louisville, Ky., he suffered a stroke and was taken to the hospital. Mr. Hutchinson was a Corporation Member voter of the American Ceramic Society.

Corporation Members of the American Ceramic Society who have paid their minimum fee of $25.00 for the year 1936 will receive a membership certificate similar to the one shown in this illustration. This certificate, signed by the President and General Secretary of the Society, framed and ready for hanging, will be sent immediately on payment of 1936 Corporation fees.



MEMBERSHIP STATUS

	December 31	January 31
Paid in Full		
Personal	1248	1276
Corporation	187	187
Honorary, Life, and Complimentary	26	26
Deferred Personal	26	24
Part-Payment Personal	46	42
Subscribers	488	491
Advertisers	37	39
Current Sales	225	225
Total	2283	2310

Dated, signed, and framed, the certificates of Corporation Membership in the American Ceramic Society are shown in the photograph to the left. Certificates for all of the Corporations now contributing to the support of the Society are ready.

COMMUNICATIONS—CERAMIC HISTORY

THE CARE OF CHINA*

By Edward Schramm

I. Introduction

Attractiveness in the china service is a valuable asset to any restaurant or other institution. An appreciation of fine china is universal and any inferiority is quickly observed by the public. China plays a part in the general decorative plan and can often be made an integral part of such plan. It may also serve the purpose of creating a favorable psychological reaction, helping to develop the sensation of pleasure which should accompany the eating of a meal. These considerations may seem remote from the subject under discussion, but in reality the connection is close. Thought given to the care of china will prolong its useful life, reduce the cost of maintenance, and make it possible to employ more beautifully decorated services without prohibitive expense. So the question of proper care has a vital bearing on the preceding question of the choice of ware and decoration. Its importance from the utilitarian point of view is too obvious to need discussion. From either standpoint, the use of good judgment in the original selection will ease the problem of the user, and we shall give data which may assist in this direction.

II. Faults Developed

Frequently we see china in service which looks worse after a comparatively short period of use than it should look after years of use under proper conditions. The faults developed are of two general kinds: first, mechanical failures, ranging from unsightly chips and cracks to complete breakage and second, impairment of appearance without mechanical failure, such as discoloration of the body, wearing off of the decoration, or scratching and dulling of the glaze.

The first of these is the more obvious, but is nevertheless a real problem. In some institutions each piece of china is handled as many as ten times in the service of a single meal, and if an average of ten meals per day were served the ware is handled one hundred times in the course of a single day. This frequent handling, as will be pointed out later, has an important bearing on the question of maintaining appearance and it may also lead to excessive breakage if there is any carelessness. No cure-all can be prescribed; it is a matter of *esprit de corps* in the staff. A few pitfalls may be pointed out. Adequate, convenient, and properly organized storage facilities for the various items are indispensable. The price of confusion is high. Where washing machines are used, they should be of a type which does not permit the ware to rattle around. Cups and saucers deserve special attention since they are subject to more abuse than any other items.

* Received January 11, 1936.

III. Design and Shape

The design and shape should be adapted to the needs of the particular service. Where this is severe the standard rolled-edge restaurant ware should be used. For intermediate conditions there are available light rolled-edge and plain-edge medium weight ware. For the exceptional case where conditions approximate those of a well-run private household, thin dinnerware may be employed, but it must be recognized that this is rarely advisable in a public eating place. Whatever weight is selected should be consistently adhered to throughout the service. There is nothing more damaging than a mixture of heavy and light items, the latter suffering severely from blows by the former. For any given weight standard, a good make of American vitrified china will give the best service since it is much stronger than earthenware and less brittle than European chinas.

The reinforced or rolled edge is designed to minimize chipping, but in spite of the strength of the ware, chipping is not uncommon. Some makers have met this situation by flattening the leaves of the plates. Such flat-leaved plates are more pleasing in appearance and have the important advantage that any chipping which occurs is usually on the under side and does not render the ware unsightly for use.

As already noted, cups are troublesome due partly to the practice of nesting them in high stacks which easily topple over. If the nesting is not done with care a hard blow is delivered in the operation and handle breakage may result. For these reasons the storage of cups in single layers in wooden trays is recommended. Where there is handle breakage which can not be corrected by ordinary care, a remedy may be found in the use of cups with handles welded to the body. Such cups are available on the market.

IV. Maintenance of Appearance

While the prevention of mechanical losses is essential, the maintenance of the original brilliant, lustrous appearance of the ware is equally important and presents varied problems. The maintenance of appearance may be taken up under three headings dealing with decoration, body, and glaze.

Decoration

China decorations are of two types, overglaze and underglaze. The overglaze decorations, when well fired and done in suitable colors will give good service in ordinary household use, but they are totally unequal to the demands of restaurant service. They are subject to mechanical abrasion and to attack by acids in foods and by alkalis in

washing compounds. The underglaze decorations are, of course, indestructible and most suitable for hard use.

Body

Appearance as influenced by the body is a question of vitrification. Good restaurant ware should be nonporous, by which we mean that the water absorption should be less than $^1/_{10}$ of 1% in the case of the ordinary service items. Even a slightly porous ware will absorb grease and other impurities into the body, eventually leading to a condition which is both unsightly and unsanitary. The porosity of the body may be tested by placing a drop of ink on the exposed fracture of a broken piece, allowing it to dry, and washing it off with water. If the body is porous a pronounced stain will remain which can not be washed off.

Glaze

The third item, the maintenance of glaze and surface conditions generally, is the most difficult problem with which the user of china has to contend and warrants a more extended discussion. Badly scratched china is a matter of frequent occurrence. Although the glaze on well-made china is extremely hard, in fact much harder than a knife blade or any other metal, it is true that one piece of ware may scratch another if they are rubbed together, especially if force or pressure is applied. The situation is analogous to the scratching of a diamond by a diamond. In the case of ware with an unglazed foot there is an extra hazard due to the fact that such a foot, is more or less rough and that the body is even harder than the glaze and will produce a scratch more readily than two glazed surfaces brought in contact. Once the glaze has become scratched there is, of course, no way of curing the defect, so we must rely entirely on the ounce of prevention provided by careful handling. Avoid the sliding of one piece on another. Do not pile too high and move the ware around while subjected to heavy pressures. Do not use a machine in which the pieces slide on one another. Bad scratching may be caused by abrasive scouring powders. These should not be used under any circumstances.

A scratched or abraded glaze provides a surface which holds dirt causing discoloration and, generally speaking, emphasizes certain other difficulties to be discussed. The discoloration can be removed by suitable treatment to be described, but the original luster of the glaze can never be restored.

One type of surface discoloration is caused by metal marking. Since there is no metal as hard as the glaze of the ware, there is no metal which cannot leave a deposit on the roughened surface of the ware, but, naturally, the harder metals are less offensive in this respect than are the softer. For this reason, aluminum is by far the worst offender and contact of china with aluminum should be avoided as much as possible. Zinc also is rather soft and is not much better than aluminum, especially if not kept clean. Nickel, including nickel plate, and monel metal are less harmful than aluminum and zinc. Stainless steel, if it is hard, is comparatively harmless, but it should be remembered that all stainless steel is not especially hard. Laboratory tests on chromium plating indicate that it should prove very good because in hardness it is nearer the glaze than any other metal known.

The most satisfactory solution of the problem of metal marking seems to be to keep the china from contact with metal as much as possible. We have tested trays of materials in the nature of Bakelite and Micarta and find these materials to be very promising. They are not rubbed badly by chinaware and any marks which may come from them are easily removed. Moreover, materials of this nature are much lighter than metals, have a lower heat conductivity, are easily washed clean, and are pleasing in appearance. In general, metal should be avoided in accessory furnishings such as table tops and racks, and the propensity to metal marking considered in the construction of washing machines.

Precautions in Washing

Thus far we have discussed only mechanical effects, but there are also chemical effects to consider which are sometimes difficult to deal with. These include formation of lime scale, deposition of mineral sediment from waters, formation of adherent food stains, and etching of the glaze. These difficulties may be combated from two directions: (*a*) through improving the conditions under which the work is done, and (*b*) by using the best washing powder obtainable. Under (*a*) the important items to consider are:

(1) *Nature of water supply.* Very hard waters tend rapidly to build lime scale; the installation of a water softener is probably the best solution of this problem. Much smaller quantities of washing powders are then adequate and, in addition to the resulting improved appearance and life of the ware, the reduction in cost of washing powders may be considerable. Muddy water will leave sediment on the ware and such water should be clarified before use.

(2) *Temperature of washing solution.* Extreme temperature should be avoided since it promotes the formation of lime scale and increases the tendency of the washing solution to attack the glaze; 150°F may be considered a suitable working temperature.

(3) *Rinsing conditions.* Copious rinsing is indispensable and the ware must not be permitted to dry between the washing and rinsing operations.

(4) *Concentration of washing compound.* With any compound, an excessive amount may damage the glaze. The quantity needed depends on the nature of the water, but as a rule $^1/_4$ to $^1/_2$% is sufficient, *i.e.*, $^1/_3$ to $^2/_3$ ounces per gallon of water.

Ordinarily, washing conditions are not ideal, so that our general item (*b*), the selection of the best washing powder, becomes practically of the greatest importance. The washing operation must be so carried out that the following conditions are met:

(1) Grease must be dissolved and removed.
(2) Solid dirt must be suspended and carried off.
(3) The solution must not deposit lime scale or other sediment on the ware.
(4) The washing solution must rinse off freely, leaving no residue behind.
(5) The solution must not have any appreciable tendency to attack the glaze.

Before the advent of the washing machine, the above conditions were best met by the use of a neutral soap. The use of soap is impossible in machines because of the frothing action, so that the use of mineral cleaners has become universal. The earlier cleaners were all unsatisfactory with respect to one or more of the desired requirements and it is only within very recent years that a satisfactory solution of the problem has been reached.

The three common available mineral cleaners are carbonate, phosphate, and silicate of soda. The first is lowest in cost per pound but is the least efficient of the three. It must be used in greater amount which is in itself objectionable, and with hard water it will produce a firm, dense lime scale on the ware. For cleansing efficiency, sodium metasilicate takes first place, and has very little tendency to form precipitates with the lime in the water. Trisodium phosphate is intermediate between carbonate and silicate in effectiveness. It forms a loose, bulky precipitate with the lime in the water; such a precipitate is less objectionable than the hard carbonate scale but is a source of danger since it may adhere as a sediment and slowly build up. Recently, two new forms of phosphate known as pyrophosphate and metaphosphate have been introduced. When these are added in sufficient quantity to trisodium phosphate or sodium metasilicate cleaners, the lime is held in solution and danger from that source eliminated.

One action which may occur is the combination of lime in the water with grease in foodstuffs to form insoluble lime soaps, which deposit on the ware. Phosphates prevent this action by combining with the lime, whereas silicates are totally ineffective in this respect. The latter must therefore not be used alone but always in conjunction with phosphates.

The question of rinsing is especially important with silicate cleaners. If sodium metasilicate is allowed to dry on the ware, a film may form which cannot later be removed. When sufficient phosphate is used with the silicate the tendency to leave tenacious deposits is overcome, and we have had reports of very good results in service from such cleaners. In some cases ammonia salts or other special materials are added to serve as "wetting" agents which cause spreading of the film and improve rinsing action.

Probably the most important of the recent developments has been the introduction of the special phosphates, already noted above, which prevent precipitation of lime. These are effective as additions either to a trisodium phosphate or sodium metasilicate base. Where aluminum utensils are washed in the same water as the dishes, the silicate has the advantage of reducing attack on the metal.

The practice of buying the cheapest cleaner is the poorest kind of economy. Products are available on the market which utilize some or all of the new developments referred to above, and these naturally must be sold at somewhat higher prices. Improved maintenance of china will more than pay the added cost.

A common cause of discolored ware is the practice of placing china on hot plates or otherwise overheating the ware. Fat or other food material may thus be burnt on so that it is impossible to remove. Plates can be warmed in suitable warming ovens without incurring this danger. Tea or coffee allowed to dry on the ware may leave a stain which is difficult to remove.

A glaze which has become scratched through careless handling is more easily attacked by washing solutions and affords a surface which retains tenaciously the various kinds of discoloration, whether metal marking, scale, sediment, or food film. Therefore care in handling is one of the valuable means of avoiding these secondary effects.

Surface discolorations of the types mentioned which are not removed by the ordinary washing operation can be taken care of by special treatments. The most common of the discolorations is that due to food stain and the safest method for its removal is through the use of weak hypochlorite solutions. Common bleaching powder (calcium hypochlorite) may be used, but sodium hypochlorite is more effective and convenient. It can be obtained in the form of a solution or in powder form, and in either case is to be suitably diluted with water. The hypochlorite solutions must be kept out of contact with metal; stoneware or enameled containers should be used and rubber gloves worn for handling. This treatment is for occasional use only; the frequency will be determined by local conditions. Where for some reason the hypochlorite treatment cannot be applied, the ware should be washed and wiped by hand at regular intervals using, but only if necessary, a soft powder such as Bon Ami to assist in removal of film.

The hypochlorite treatment kills all bacteria and is, therefore, an excellent thing from a sanitary standpoint. Recent medical investigations have shown that a minute amount of chlorine used regularly in the rinse water will maintain the dishes in a sterile condition. We are not aware that this practice is anywhere in effect today, but it appears the next logical step in the maintenance of china in public places.

Mineral sediments do not respond to the hypochlorite treatment. Sometimes these can be removed directly by Bon Ami, but in extreme cases it is necessary to soak the ware in weak acid such as vinegar or a 5% hydrochloric acid solution. Following the acid soak, a gentle scouring with Bon Ami will remove the sediment.

V. Summary

To summarize, we shall set down in the form of a table the main items in the proper care of china:

(1) Careful handling; avoid as much as possible rubbing or sliding pieces against one another.
(2) Provide adequate, convenient, and well-organized storage.
(3) Use soft water if possible.
(4) Use mild washing powders and no more than needed.
(5) Use washing powders of best quality, avoiding especially powders which form lime scale.
(6) If film does form on ware, remove periodically either by sodium hypochlorite treatment or hand washing.
(7) Avoid heating wash water above 150°F.
(8) Avoid contact with soft metal, such as aluminum or zinc.
(9) Avoid overheating ware on hot plates or in ovens.

Onondaga Pottery Company
Syracuse, New York

After a considerable Period of Time spent in Research, SIMPLEX wishes to announce that the SIMPLEX Interlocking Suspended Arch positively will not fall into the metal or product being manufactured in Glass Tanks and Steel Furnaces.

SIMPLEX EQUIPMENT CREATES REPEAT ORDERS AND RETAINS PRESTIGE

SIMPLEX
ENGINEERING COMPANY

WASHINGTON TRUST BLDG. WASHINGTON, PENNA, U. S. A.

Product Finish Insurance

THERE is satisfaction in knowing that the frit you buy is of the finest quality and that the service is dependable.

There is greater satisfaction in knowing that the frit is *uniformly* fine and that the service is *consistently* dependable.

When you buy Lusterlite Frit you buy *product finish insurance.*

CHICAGO VITREOUS ENAMEL PRODUCT CO.
CICERO ILLINOIS

LUSTERLITE ENAMELS

CLAYS
English China and Ball

TALCS
for
HEATING ELEMENTS
CERAMIC BODIES
SAGGER USES

Ceramic Specialties Include
Whiting : Paris White : Magnesite
Cornwall Stone : Barium Carbonate
Zinc Oxide : Enameling Clays : Etc.

HAMMILL & GILLESPIE, INC.
Importers since 1848
225 Broadway New York

PAPER MAKERS IMPORTING CO. INC.
EASTON, PENNSYLVANIA, U.S.A.

FINEST
POTTERY CLAYS

CONTINUING EDUCATION AND KEEPING POSTED REQUIRES:

(a) Keeping posted in principles and practices—not "stuffing in" but "leading out"—i.e. sound thinking

(b) Keeping daily records—a complete diary of thought experiences

(c) Surveying breadth and depth of knowledge on the particular subject by writing reports to one's intellectual superior

(d) Keeping informed on what others in the same and in bordering fields are doing

(e) Active participation in professional societies composed of men in the same and allied lines

in other words

BY ACTIVE PARTICIPATION IN THE AMERICAN CERAMIC SOCIETY

with its eight Industrial Divisions covering

CLAY GLASS ENAMELS

BORAX *Guaranteed 99½%–100% Pure* BORIC ACID

Select the Brand which has back of it years of *successful use* by experienced Ceramists

Pacific Coast Borax Co., New York

Chicago **Los Angeles**

BACK NUMBERS
OF
JOURNAL OF AMERICAN CERAMIC SOCIETY
AND ALL IMPORTANT MAGAZINES FROM THE WORLD OVER

We furnish single copies, volumes and sets or photostat reproductions of specific sections, reasonably and promptly

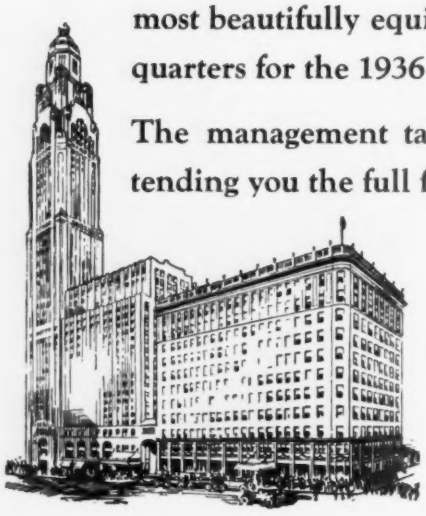
WRITE, PHONE OR WIRE PERIODICALS DEPARTMENT

THE H. W. WILSON COMPANY 950 University Avenue, New York

Ceramic Headquarters
For 1936

The Deshler-Wallick Hotel, internationally known as America's most beautifully equipped hotel, has been chosen as general headquarters for the 1936 American Ceramic Society Meeting.

The management takes great pleasure, at this early date, in extending you the full facilities of this magnificent hotel.



1000 Rooms 1000 Baths

DESHLER-WALLICK
Columbus Ohio

L. C. Wallick, Pres. Jas. H. Michos, Res. Mgr.

Abrasives
Carborundum Co. (*Carborundum and Aloxite*)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Norton Co. (*Alundum-Crystalon*)

Air Conditioning Systems
Simplex Eng. Co.

Aloxite (Refractory Products)
Carborundum Co. (*Alundum-Crystalon*)
Chicago Vitreous Enamel Product Co.

Alumina (Hydrate and Calcined)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Aluminum Oxide (Fused)
Carborundum Co.
The Exolon Co.
The Hommel Co., O., Inc.
Norton Co.
The Vitro Mfg. Co.

Alundum (Refractory Products)
Norton Co.

Ammonium Bicarbonate
Solvay Sales Corp.

Ammonium Bifluoride
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Ammonium Carbonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.

Antimony Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co

Arches (Interlocking, Suspending, and Circular)
Simplex Eng. Co.

Automatic Brick Car Loaders
Lancaster Iron Works, Inc.

Ball Mills
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
McDanel Refractory Porcelain Co.
The Vitro Mfg. Co.

Ball Mills (Laboratory Type)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Barium Carbonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Batch Systems
Lancaster Iron Works, Inc.
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Batts
Carborundum Co. (*"Carbofrax Aloxite"*)
Denver Fire Clay Co.
Norton Co. (*Alundum-Crystalon*)

Bitstone
Consolidated Feldspar Corp.
Potters Supply Co.

Blocks (Refractory)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.

Borax
American Potash & Chemical Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Borax Glass
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Boric Acid (Anhydrous)
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Vitro Mfg. Co.

Boric Acid (Crystal, Granular, or Powder)
American Potash & Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Boron Carbide
Norton Co.

Brick Machines (also Barrows, Molds)
Lancaster Iron Works, Inc.

Brick (Refractory)
Carborundum Co. (*"Carbofrax Aloxite"*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
The Vitro Mfg. Co.

Carbofrax (Refractory Products)
Carborundum Co.
Chicago Vitreous Enamel Product Co.

Carbolon (Refractory Products)
The Exolon Co.

Carbonates (Barium, Lead)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co
The Vitro Mfg. Co.

Castings
Lancaster Iron Works, Inc.

Castings (Abrasive Resisting)
Bethlehem Steel Corp.

Castings for Molds and Plungers
Simpson Foundry & Eng. Co.

Caustic Potash
Solvay Sales Corp.

Caustic Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co
Solvay Sales Corp.
The Vitro Mfg. Co.

Cements
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Norton Co.
Pittsburgh Plate Glass Co.

Ceramic Chemicals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Chromium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay (Ball)
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Potters Supply Co.
The Roessler & Hasslacher Chemical Co.
Spinks Clay Co., H. C.
The Vitro Mfg. Co.

Clay (China)
Ceramic Color & Chemical Mfg. Co
Consolidated Feldspar Corp.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay—Cleaners, Feeders
Lancaster Iron Works, Inc.

Clay (Electrical, Porcelain)
Ceramic Color & Chemical Mfg. Co.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay (Enamel)
Ceramic Color & Chemical Mfg. Co
Chicago Vitreous Enamel Product Co
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Ferro Enamel Corp.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Metal & Thermit Corp.
Paper Makers Importing Co.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Spinks Clay Co., H. C.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Clay (Fire)
Chicago Vitreous Enamel Product Co
Denver Fire Clay Co.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Clay (German Vallendar)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co
Ferro Enamel Corp
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay Miners
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Potters)
Denver Fire Clay Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Process Equipment)
Bonnot Co.
Lancaster Iron Works, Inc.

Clay (Sagger)
Edgar Brothers Co
Edgar Plastic Kaolin Co.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co
Pittsburgh Plate Glass Co.
Potters Supply Co
Spinks Clay Co., H. C.

Clay (Wad)
Kentucky-Tennessee Clay Co.
Potters Supply Co
Spinks Clay Co., H. C.

Clay (Wall Tile)
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clocks (Gauge Board)
Chicago Vitreous Enamel Product Co
Ferro Enamel Corp.
The Hommel Co., O., Inc

Cobalt Oxide
Ceramic Color & Chemical Mfg. Co
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co

Colors
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Cones
The Edward Orton, Jr., Ceramic Foundation

Conveying Equipment
Lancaster Iron Works, Inc.
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Corhart
Corhart Refractories Co.

Cornwall Stone (Imported)
Consolidated Feldspar Corp.
Drakenfeld & Co., B. F.

Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Crucibles (Filter, Melting, Ignition)
Carborundum Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Crushers (Clay)
Lancaster Iron Works, Inc.

Crystolon (Refractory Products)
Norton Co.

Cullet, Washing Plants, Incinerators, Crushers
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Decorating Supplies
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Disintegrators
Lancaster Iron Works, Inc.

Dryer (Pipe Rack)
Lancaster Iron Works, Inc.

Drying Machinery
Ferro Enamel Corp.
Lancaster Iron Works, Inc.

Electrocast Refractories
Corhart Refractories Co.

Enameling Equipment (Complete)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Enameling Furnaces
Carborundum Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Lancaster Iron Works, Inc.
Norton Co.
Porcelain Enamel & Mfg. Co.

Enameling Iron (Sheet)
American Rolling Mill Co.

Enameling Muffles
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Norton Co. (*Alundum*)
Pittsburgh Plate Glass Co.

Enameling (Practical Service)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Enamels (Porcelain)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Equipment (Porcelain Enameling)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Exolon (Refractory Products)
Ferro Enamel Corp.
The Exolon Co.

Feldspar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Finishing Tools
Simpson Foundry & Eng. Co.

Fire Brick
Carborundum Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
Norton Co.

Fire Brick—Process Equipment
Lancaster Iron Works, Inc.

Fire-Polishing Machines
Simpson Foundry & Eng. Co.

Flint
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Flint Pebbles
Chicago Vitreous Enamel Product Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.

Floors (Non-Slip)
Norton Co.

French Flint
Consolidated Feldspar Corp.
Paper Makers Importing Co.

Frit
Allied Engineering Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Fuel Oil Systems and Control, Stokers
Simplex Eng. Co.

Furnaces
Allied Engineering Co.
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Glass Bending Ovens, Glass Decorating Machines
Simplex Eng. Co.

Glass Equipment
Hartford-Empire Co.
Lancaster Iron Works, Inc.
Simpson Foundry & Eng. Co.

Glass Melting Tanks and Furnaces
Simplex Eng. Co.

Glass Thickness Gauge
Bausch & Lomb Optical Co.

Glaze and Body Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Glaze Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Goggles
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Granulators
Lancaster Iron Works, Inc.

Grinding Mills
Simpson Foundry & Eng. Co.

Grinding Wheels
Carborundum Co. (*Carborundum and Aloxite*)
Norton Co. (*Alundum-Crystalon*)

Hearths
Carborundum Co.
(*Carbofrax* heat treating)
Norton Co. (*Crystalon*)

Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Norton Co.

Iron (Enameling)
American Rolling Mill Co.

Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Kaolin
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Kettles of All Kinds
Simpson Foundry & Eng. Co.

Kilns, China (Decorating)
Allied Engineering Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.

Kryolith
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Ladles (Cast-iron)
Simpson Foundry & Eng. Co.

Lehr Tile (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.

Lehrs
Simpson Foundry & Eng. Co.

Lehrs (Electric or Fuel Heated)
Simplex Eng. Co.

Lehr Loaders
Simpson Foundry & Eng. Co.

Linings (Furnace Refractory, Block Refractory Plate, Brick and Tile)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.

Magnesia (Sintered, Calcined)
Drakenfeld & Co., B. F.
The Exolon Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Norton Co.

Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.

Manganese
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Manganese (Oxide)
The Roessler & Hasslacher Chemical Co.

Masks (Breathing)
Willson Products, Inc.

Metals (Porcelain Enameling)
American Rolling Mill Co.

Microscopes (Polarizing)
Bausch & Lomb Optical Co.

Minerals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Mixers (Batch)
Lancaster Iron Works, Inc.

Mold Sanders
Lancaster Iron Works, Inc.

Muffles (Furnace)
Allied Engineering Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Mullite (Artificial)
The Exolon Co.

Muriatic Acid
Denver Fire Clay Co.
The Hommel Co., O., Inc.

Nitrates (Cobalt, Sodium)
Ceramic Color & Chemical Mfg. Co
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co
The Vitro Mfg. Co.

Norbide (Norton Boron Carbide)
Norton Co.

Olivine
The Roessler & Hasslacher Chemical Co

Opacifiers
Ceramic Color & Chemical Mfg Co
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Oxides
Ceramic Color & Chemical Mfg Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Pins
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Potters Supply Co

Polariscope
Bausch & Lomb Optical Co.
Simpson Foundry & Eng. Co.

Porcelain Enameling Service (Practical)
American Rolling Mill Co.
Ceramic Color & Chemical Mfg. Co
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Porcelain Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co
The Roessler & Hasslacher Chemical Co
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Potash (Carbonate)
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Pot-setting Tools
Simpson Foundry & Eng. Co.

Presses, Side-lever and Bench
Simpson Foundry & Eng. Co.

Producer Glass Plants
Simplex Eng. Co.

Pug Mills
Lancaster Iron Works, Inc.

Pyrometer Tubes
Carborundum Co.

Pyrometer Tubes (Refractory and Hard Porcelain)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Norton Co.

Pyrometric Cones
The Edward Orton, Jr., Ceramic Foundation

Raw Material Handling Equipment
Lancaster Iron Works, Inc.
Simpson Foundry & Eng. Co.

Refractometers
Bausch & Lomb Optical Co.

Refractories
Carborundum Co
Corhart Refractories Co
Denver Fire Clay Co.
The Exolon Co
Norton Co.
Pittsburgh Plate Glass Co.

Refractory Materials
Carborundum Co
Chicago Vitreous Enamel Product Co
Denver Fire Clay Co.
The Exolon Co
Kentucky-Tennessee Clay Co
Norton Co.
Pittsburgh Plate Glass Co.
Titanium Alloy Mfg. Co.

Represses (Automatic)
Lancaster Iron Works, Inc.

Respirators
Willson Products, Inc.

Rutile
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Saggers
Carborundum Co.
Norton Co.
Potters Supply Co.

Salt Cake
American Potash & Chemical Co.

Sand Grinder and Sifters
Lancaster Iron Works, Inc.

Saponin
Jungmann & Co., Inc.

Selenite of Sodium
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Selenium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sheets (Enameling Iron)
American Rolling Mill Co.

Silica (Fused)
The Exolon Co.
The Hommel Co., O., Inc.

Silicate of Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Philadelphia Quartz Co

Silicon Carbide
Carborundum Co.
The Exolon Co.
Norton Co.

Silicon Carbide Firesand
Carborundum Co.
The Exolon Co.

Sillimanite (Synthetic)
The Exolon Co.
Pittsburgh Plate Glass Co.

Slabs (Furnace)
Carborundum Co
Norton Co

Smelters
Ferro Enamel Corp.
Porcelain Enamel & Mfg. Co.

Soda Ash
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Fluoride
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Silica Fluoride
Jungmann & Co.

Soot Blowers
Simpson Foundry & Eng. Co.

Special Machines
Simpson Foundry & Eng. Co.

Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Spurs
Potters Supply Co.

Stacks
Lancaster Iron Works, Inc.

Steel Plate Construction
Lancaster Iron Works, Inc.

Stilts
Potters Supply Co

Sulfuric Acid
Denver Fire Clay Co.
The Hommel Co., O., Inc.

Talc
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co
The Roessler & Hasslacher Chemical Co.

Tank Blocks
Corhart Refractories Co.

Tanks (Pickle)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.

Tanks for Raw Material Steel or Concrete
Lancaster Iron Works, Inc.
Simpson Foundry & Eng. Co.

Tile (Floor)
Norton Co.

Tile (Muffle)
Carborundum Co
Norton Co.

Tile (Refractory)
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.

Tile (Wall)
Denver Fire Clay Co.
Ferro Enamel Corp.

Tin Oxide
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Titanium
Ceramic Color & Chemical Mfg Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Titanium Oxide
Ceramic Color & Chemical Mfg. Co
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Trucks
Lancaster Iron Works, Inc.

Tubes (Insulating)
Carborundum Co.
McDanel Refractory Porcelain Co.
Norton Co.

Tubes (Pyrometer)
Carborundum Co.
Denver Fire Clay Co.
McDanel Refractory Porcelain Co
Norton Co.
Pittsburgh Plate Glass Co.

Valves (Butterfly and Reversing)
Simpson Foundry & Eng. Co.

Water Softening Plants
Simplex Eng. Co.

Wet Enamel
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Whiting
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Winding Drums
Lancaster Iron Works, Inc.

Zinc Oxide
Jungmann & Co., Inc.

Zirconia
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

ALPHABETICAL LIST OF ADVERTISERS

	Page
Allied Engineering Co.	2
American Potash & Chemical Corp.	16
American Rolling Mill Co.	Inside Front Cover
Buyers' Guide	9
Ceramic Color & Chemical Mfg. Co.	16
Chicago Vitreous Enamel Product Co.	6
Corhart Refractories Co.	4
Denver Fire Clay Co.	12
Deshler-Wallick Hotel	8
Du Pont de Nemours, E. I., & Co.	19
Edgar Bros. Co.	2
Edgar Plastic Kaolin Co.	2
Edward Orton, Jr., Ceramic Foundation	14
Ferro Enamel Corp.	3
Hammill & Gillespie, Inc.	6
Hartford-Empire Co.	15
Hommel, O., Co., Inc.	13
Ironton Chamber of Commerce	20
Journal Society of Glass Technology	3
Lancaster Iron Works	18
McDanel Refractory Porcelain Co.	16
Metal & Thermit Corp.	Outside Back Cover
Montgomery Porcelain Products Co.	14
Neil House	13
Orton, Edward, Jr., Ceramic Foundation	14
Pacific Coast Borax Co.	8
Paper Makers Importing Co.	6
Pittsburgh Plate Glass Co	13
Porcelain Enamel & Mfg. Co.	2
Potters Supply Co.	15
Professional Directory	14
Roessler & Hasslacher Chem. Co	19
Simplex Engineering Co.	5
Solvay Sales Corp.	15
Spinks, H. C., Clay Co.	Inside Back Cover
Tables Annuelles de Constantes	17
Vitro Mfg. Co.	3
Willson Products, Inc.	14
Wilson, H. W., Co.	8

High temperatures quickly and safely

DFC No. 100 TEST KILN

Ideal for experimental and development work.

Write for data.

THE DENVER FIRE CLAY COMPANY

DENVER DFC COLO. U.S.A.

BRANCHES AT SALT LAKE CITY, EL PASO, AND NEW YORK

ATTENTION

ADVERTISERS and PROSPECTIVE ADVERTISERS

The March issue of The Bulletin will contain the complete program for the Annual Meeting of The American Ceramic Society.

Prospective Advertisers:
You will want a sales message in this issue.

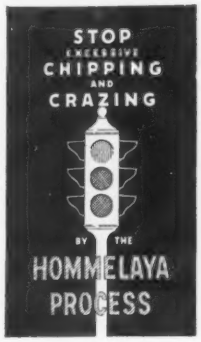
Advertisers:
You will want to increase your ad space in this issue.

THE HOUSE OF HOMMEL
Suppliers of All Ceramic Needs

Control Makes Uniformity
Satisfied Customers Attest It

The one-room office of 1891 has become a 7½ acre plant. The scattered bronze powder customers of 1891 have become a group located throughout the world, and representing every phase of ceramic activity.

The product uniformity that brought this growth was the result of the elaborate control methods developed by the House of Hommel. Careful checking of every raw material, continuous tests at every stage of every manufacturing process, assure that uniformity which simplifies your manufacturing problem. Ask the representative for full details.



The O. HOMMEL CO.
Quality First—Since 1891
209 Fourth Avenue Pittsburgh, Pa.
Let Others Imitate—We Originate

PACIFIC COAST AGENTS
L. H. Butcher Co.
Los Angeles Portland Seattle Salt Lake City San Francisco

● WE MAKE

Glass House Refractories

Flux Blocks
Pots Open & Covered
Refractory Blocks
Highlands Pot Clays
Prepared Mixes
Special Batches

P. B. Sillimanite

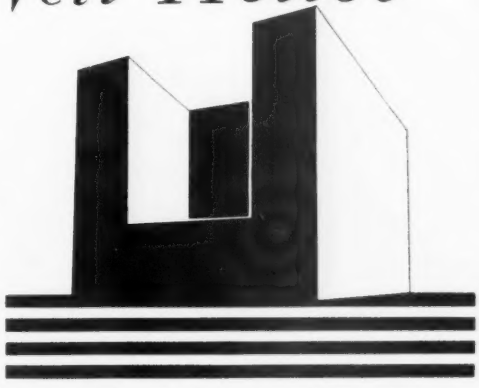
Standard Sizes and Shapes to Order

● WE SELL

● WE USE OUR OWN

PITTSBURGH
PLATE GLASS COMPANY
Refractories Division
GRANT BUILDING, PITTSBURGH, PA.

The Neil House



Columbus, Ohio

Headquarters for the Art, Glass, Structural Clay Products, and Whitewares Divisions

Reservations are being made now for the 1936 Annual Meeting of the American Ceramic Society.

The Neil House is located in the heart of the city, 655 rooms, all with bath. Rates $2.50 and up single, $3.50 and up double, twins $5.00 and up, suites $7.00 and up. Real hospitality—affording comfort and convenience—three popular restaurants, prompt counter and table service.

TOM A. SABREY
Vice Pres. and Manager

A DeWitt Operated Hotel

MONTGOMERY PORCELAIN PRODUCTS CO.
Specializing in
Primary Protection Tubes for all makes of Pyrometers
"Corundum" "Mullite" "Silicon Carbide" "Refractory Porcelain"
FRANKLIN OHIO

THE SHARP-SCHURTZ COMPANY
CHEMISTS FOR THE CERAMIC INDUSTRY
WE HAVE FULLY EQUIPPED LABORATORIES AT
LANCASTER, OHIO U. S. A.

EMERSON P. POSTE
CONSULTING CHEMICAL ENGINEER
ANALYSES: CERAMIC RAW MATERIALS AND PRODUCTS, FUELS, IRON AND STEEL, ETC.
SPECIAL INVESTIGATIONS: PHYSICAL AND CHEMICAL TESTS ON ENAMEL, ETC.
309 McCALLIE AVE.,
CHATTANOOGA, TENN.

COMMERCIAL TESTING ● RESEARCH ● ANALYSES
BAILEY & SHARP CO., INC.
CHEMISTS, CONSULTING ENGINEERS, GLASS TECHNOLOGISTS
SPECIALIZING IN NEW AND UNUSUAL ENGINEERING AND CHEMICAL PROCESSES AND IN ORIGINAL DEVELOPMENTS IN THE CERAMIC FIELD.
HAMBURG, N. Y. U. S. A.

ORTON STANDARD PYROMETRIC CONES

For Thirty-Nine Years
The American Standard for
Control of Ceramic Heat Treatment
THE EDWARD ORTON, JR., CERAMIC FOUNDATION
George A. Bole, D.Sc., *Manager*
Laboratories & Office
1445 Summit Street—Columbus, Ohio

NON-METALLICS AND RARER ORES
INSPECTION AND EVALUATION OF PROPERTIES
CHEMICAL AND PETROGRAPHIC ANALYSES
INSPECTION & RESEARCH LABORATORIES
J. T. ROONEY, B.S. Chemical & Mining Engineer
A. E. ALEXANDER, PH. D. Mineralogist & Geologist
30 CALUMET BLDG., BUFFALO, N. Y.

WILLSON BAG RESPIRATORS
Nos. 300 and 400 (Patent applied for) have
UNITED STATES BUREAU OF MINES APPROVALS
A Willson style for every dusty operation in the Ceramic Industry.
WILLSON PRODUCTS, Inc. **Reading, Pa.**

HARTFORD-EMPIRE COMPANY
HARTFORD, CONN.

Engineers and Licensors

FEEDERS FORMING MACHINES CONVEYORS
STACKERS LEHRS

SOLVAY
TRADE MARK REG. U. S. PAT. OFF.
dustless dense
SODA ASH

Made Especially for the Glass Maker

Specify SOLVAY when you buy Soda Ash because Solvay is and has been the standard of quality since 1881. It offers the following advantages:

1. More than 99.50% Sodium Carbonate (dry basis).
2. Proper granulation and absolute uniformity in quality.
3. Your choice of Soda Ash graded for efficient use with any of the known commercial glass sands.
4. The services of a well organized technical staff which is available to Solvay customers.

Make Solvay your source of supply for
DUSTLESS CALCINED 98-100% POTASSIUM CARBONATE
Hydrated 83-85% Potassium Carbonate
Ground Caustic Potash

Full information sent on request.
SOLVAY SALES CORPORATION
Alkalies and Chemical Products Manufactured by The Solvay Process Company
40 RECTOR ST. NEW YORK

Ceramic Service? We Give It

We Manufacture—

Pins
Stilts
Thimbles
Spurs
Saggers
Crucibles
Tile for Decorating Kilns

We Sell—

Ball Clay
Sagger Clay
Wad Clay
Ground Fire Clay
Bitstone
Fire Brick
Imported Paris White
Domestic Whiting
Pottery Plaster
Georgia Kaolin

THE POTTERS SUPPLY COMPANY
EAST LIVERPOOL, OHIO

McDANEL REFRACTORY PORCELAIN COMPANY

Manufacturers of

PORCELAIN TUBES PROTECTION TUBES
INSULATING TUBING and BEADS

BEAVER FALLS PENNSYLVANIA

THREE ELEPHANT

BORAX

REG. U.S. PAT. OFF. REG. U.S. PAT. OFF.

AND BORIC ACID

GUARANTEED OVER 99.5% PURE

AMERICAN POTASH & CHEMICAL CORPORATION

70 Pine Street, New York

"CERAMIC" COLORS

Produced by Teamwork

The salesman is alive to the needs of his customers, the artist to the style trends of the times. The technician in his laboratory combines these requirements into colors and oxides worthy of carrying the "Ceramic" trade mark.

The reliability of this teamwork is the reason why "Ceramic" products are welcomed by all members of the organizations of their buyers. The shop man knows they fit his production, the salesman knows they help make his sales.

That is why wherever good ceramic products are made—"Ceramic" Colors are popular.

CERAMIC COLOR & CHEMICAL MANUFACTURING COMPANY

New Brighton Pennsylvania

THE AMERICAN CERAMIC SOCIETY

Incorporated in 1899

TO PROMOTE CERAMIC ARTS, SCIENCE, AND TECHNOLOGY
IS A CONTINUATION EDUCATIONAL "COÖPERATIVE"
IT PUBLISHES REPORTS OF ORIGINAL RESEARCHES
AND ABSTRACTS WORLD-WIDE
CERAMIC LITERATURE

Monthly Publications of The American Ceramic Society

The Journal of the American Ceramic Society } issued on
Ceramic Abstracts } the 1st

The Bulletin of the American Ceramic Society—issued on the 15th

YOUR PARTICIPATION IN THIS "COÖPERATIVE" IS SOLICITED

THE AMERICAN CERAMIC SOCIETY
2525 NORTH HIGH STREET
COLUMBUS, OHIO

Numerical Documentation

THE ANNUAL TABLES OF CONSTANTS (A.T.C.)

AND NUMERICAL DATA

Chemical, Physical, Biological, and Technological

collect, classify, and publish, since 1910, everything in Pure and Applied Natural Sciences capable of being expressed by a number

(For the period 1910–1929) the **A.T.C.** *complete and*

(since 1928) *continue* the International Critical Tables (I.C.T.)

The **A.T.C.** are absolutely necessary to all scientists.

They represent

the only one complete documentation—the most inexpensive—the easiest to consult owing to an *Index* systematically arranged which enables one to locate *at once* the data required.

For any information—any specimen—any volume on free examination

Apply immediately to

Canada and U.S.A.
The McGraw-Hill Book Company, Inc.
370 Seventh Avenue
New York, N. Y.

Other Countries
M. C. MARIE
9, rue de Bagneux
Paris VI° France

Volumes published: 1st Series—I to V—1910–1922 (5382 pages) and index (382 pages)
2nd " VI to IX—1923–1929 (7884 pages) and Index to Vol. IX (124 pages)

Specimens: Reprints of the following sections are sent free of charge: Spectroscopy—Electricity, Magnetism, and Electrochemistry—Radioactivity—Crystallography and Mineralogy—Biology—Engineering and Metallurgy — Colloids — Wireless — Photography — Geophysics — Combustible Gaseous Mixtures, Powders, and Explosives.

English versions: Beginning with Volume VII, all explanations to the tables are given both in English and French.

"Lancaster"
COUNTER CURRENT
RAPID BATCH MIXERS
Send for Bulletin No. 70-B

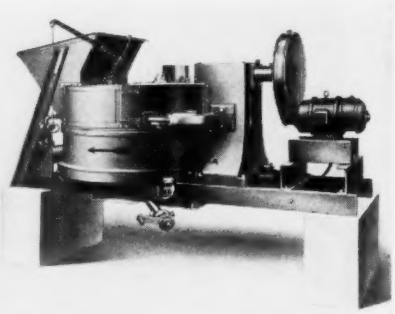
Valuable in the Refractory Industry for uniform dispersement of grains and moisture.

Valuable in the Glass Industry for perfect blending of any batch formula.

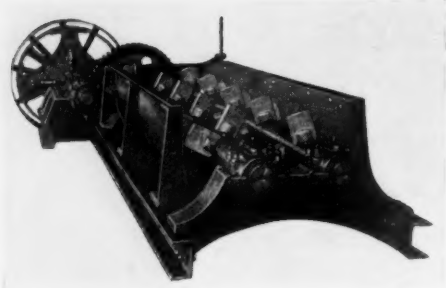
Valuable in the Ceramic Industry for thoroughly mixing components.

Valuable in the Abrasive Industry for coating grains with bakelite or other binders.

Mix . . . quicker and better . . . with a "*Lancaster.*"



The pan rotates slowly clockwise.
The mixing star, off-center, rotates counter-clockwise, rapidly.
The materials must follow a definitely charted course.
Equipped with clever central discharge valve.
Open or closed types for any desired capacity.

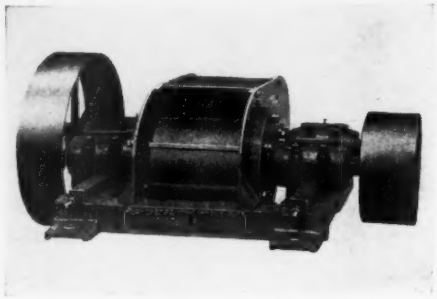


"Martin" Double Shaft Granulator.
A modernly designed machine for granulating, mixing and feeding clays uniformly.

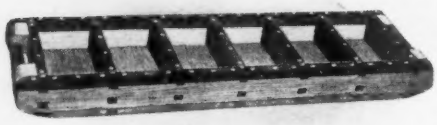
"Lancaster"
CLAY
PREPARING
MACHINERY

Clay Cleaners
Granulators
Clay Feeders
Pug Mills
Disintegrators
Crushers

Send for Bulletin No. 20



"Martin" Disintegrator.
It has features that have solved disintegrating problems for our leading refractory manufacturers.



"Lancaster" **Brick Mold.**
Made from selected air dried maple and bound with special carbon steel. Furnished in any desired size or shape for brick manufacture.

"Lancaster"
BARROWS & TRUCKS
Equipped with solid or pneumatic tires and Timken Roller Bearings.
Send for Bulletin No. 40

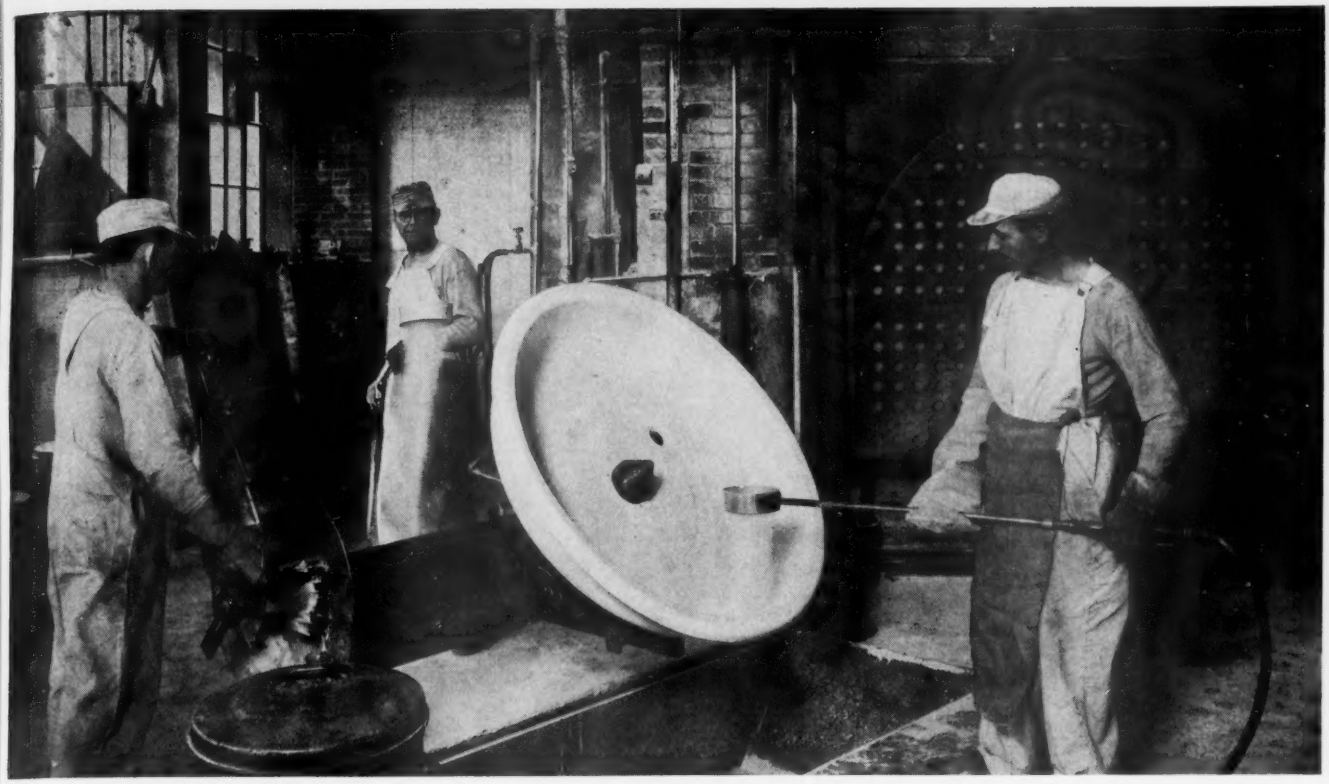
"Lancaster"
MAPLE BRICK
MOLDS
Send for Bulletin No. 40-A

"Lancaster" **Spring Truck fitted with Rubber Tired Wheel and Timken Bearings.**
We offer a wide selection of barrows and trucks.

It's Time We Got Acquainted

LANCASTER IRON WORKS, Inc., LANCASTER, PENNA.

BRICK MACHINERY AND MIXER DEPARTMENT **JAS. P. MARTIN, MANAGER**



CHEMI-TROLD* FELDSPARS

for the production of

UNIFORM PRODUCTS

CHEMI-TROLD PRODUCTS

- ★ Minpro "Chemi-Trold" Granular Glasspar
- ★ Minpro "Chemi-Trold" Semi-Granular Glasspar
- ★ Minpro and Oxford "Chemi-Trold" Ordinary 20-mesh Glasspar
- ★ Minpro and Oxford "Chemi-Trold" Pottery and Enamel Feldspar
- ★ Minpro "Chemi-Trold" Glaze Spar
- ★ Carolina Stone—A substitute for Cornwall Stone
- ★ Olivine—A natural refractory mineral rich in Magnesium
- ★ Pyrophyllite

UNIFORMITY of composition is synonymous with uniformity of results. The use of Chemi-Trold Feldspars means uniform results, better products, less waste and lower manufacturing costs.

Feldspars may look alike, but appearance is no indication that their composition meets specifications. Only through chemical control, controlled production, controlled analyses, controlled purification can you be sure of a uniform product of specified quality.

Chemi-Trold Feldspars are always uniform and definite in composition because they are produced under a process of rigid chemical control (U. S. Pat. 1,855,115). These high quality spars are guaranteed to meet individual specifications as well as all requirements of Commercial Standard C-S 23-30 issued by the Bureau of Standards.

Write for samples and further information on Chemi-Trold feldspars for glass, pottery and enamelware manufacture.

*Reg. U. S. Pat. Off.

DUPONT
REG. U.S. PAT. OFF.

E. I. DU PONT DE NEMOURS & CO., INC.

The R. & H. Chemicals Department Empire State Building, New York, N. Y.

District Sales Offices: Baltimore, Boston, Charlotte, Chicago, Cleveland, Kansas City, Newark, Philadelphia, Pittsburgh, San Francisco

Sole Selling Agent for UNITED FELDSPAR CORP.

LAWRENCE CLAY

CAN BE USED SUCCESSFULLY IN

TERRA COTTA
FACE BRICK
SALT GLAZED BRICK
ENAMELED BRICK
ACID PROOF BRICK
YELLOW WARE
STONE WARE
SEWER PIPE
SANITARY TILE
QUARRY TILE
SANITARY WARE
TABLE WARE
COOKING WARE
CONDUITS
FIREPROOFING
CRUCIBLES
REFRACTORIES
SAGGERS
FOUNDRY SANDS

MAY OUR CERAMIC ENGINEERS ASSIST YOU?

THE IRONTON CHAMBER OF COMMERCE

IRONTON, OHIO

H. C. SPINKS CLAY COMPANY

Miners and Shippers of

BALL, SAGGAR AND WAD CLAY

NEWPORT, KENTUCKY

Feb. 1, 1936

Mr. Pete Potter
Comfortable Sanitary Pottery Mfg. Co.
Pottsville, Ohio

Dear Pete:

Lucky for you that you have already adopted the use of those quality ball clays—JERNIGAN and CHAMPION and CHALLENGER ! Now that you are turning out all the ware the plant will produce, quality means a lot, and if you were using inferior and un-uniform clays the losses would cost plenty. You know we opened these two mines because exhaustive tests proved them to be most uniform deposits. That is not enough, however, so we have developed a system of mining that absolutely produces clean clay, and because we mine over large areas and thoroughly mix the clay while mining and shedding it, the clay you get is positively uniform. I can't explain all the details to you in these letters, but do hope you will come down some day so you can see for yourself. One able potter, who recently visited us, said, "You keep it clean enough to eat, and in your mining and shedding operations you are operating the Ceramic Industries' biggest mixer."

Sincerely,

Dick Carothers

M & T
Sodium Antimonate

For years M & T Sodium Antimonate has set the standard. The finest opacifier that modern methods can produce, it is always uniform, always pure. Every barrel of M & T Sodium Antimonate is exactly the same, both chemically and physically, as every other barrel.

And, this quality opacifier is more economical. Rejects, due to off colors, become rarities. Whites, whether blue white, cream white or some other hue, do not vary a shade from one year's end to the next where M & T Sodium Antimonate is used.

Our Ceramic Department will gladly help in solving your enameling problems. Homer F. Staley is manager; R. R. Danielson, director of research. Metal & Thermit Corporation, 120 Broadway, New York, N. Y.